AD-762 730

# FLIGHT TEST EVALUATION OF FOLDING SIDEWALL EXPANDABLE TIRES ON THE C-131B AIRCRAFT

Larry A. Roberts, et al

Aeronautical Systems Division
Wright-Patterson Air Force Base, Ohio

January 1973

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

14

ASD-TR-73-1

AD 762730

# FLIGHT TEST EVALUATION OF FOLDING SIDEWALL EXPANDABLE TIRES ON THE C-131B AIRCRAFT


*LARRY A. ROBERTS*
*PAUL M. WAGNER*




TECHNICAL REPORT ASD-TR-73-1



JANUARY 1973



Approved for public release; distribution unlimited.


4950TH TEST WING
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO


146

## NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.



Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

AIR FORCE/56780/17 May 1973 — 200

Unclassified

Security Classification

## DOCUMENT CONTROL DATA - R&D

*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)*

| | |
|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>4950th Test Wing<br>Aeronautical Systems Division<br>Wright Patterson Air Force Base, Ohio | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
FLIGHT TEST EVALUATION OF FOLDING SIDEWALL/EXPANDABLE TIRES ON THE C-131B AIRCRAFT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)
Larry A. Roberts
Paul M. Wagner

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| January 1973 | ~~145~~ 146 | 8 |

| | |
|---|---|
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1369(601)<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>ASD-TR-73-1<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |

10. ~~XXXXXXXXXXXXXXXXXXXXXXX~~ DISTRIBUTION STATEMENT

Approved for public release; distributed unlimited.

Details of illustrations in this document may be better studied on microfiche.

| | |
|---|---|
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Air Force Flight Dynamics Laboratory<br>Wright Patterson Air Force Base, Ohio |


13. ABSTRACT A C-131B aircraft was equipped with modified, instrumented main landing gear assemblies, and type III (low pressure), folding sidewall, 3_.5/28 x 13.0-16 aircraft tires were mounted on the main landing gear wheels. Takeoffs, landings and taxi runs were made at four different aircraft weights and at both 35% and 50% tire deflection. Braking intensity varied from light to heavy both with and without reverse pitch.

The test aircraft was equipped with an inflation/deflation system and the tires were deflated each time the landing gear was retracted and inflated each time it was extended. The tires could normally be deflated and folded within 15 seconds and reinflated within 10 seconds.

Two rollouts were made with the test tires flat and the tires demonstrated excellent runflat capability at ground speeds of up to approximately 100 knots. Directional control was good and no damage to the aircraft or to the landing gear was sustained.

The folding sidewall tires exhibited excellent tread wear qualities. Following removal from the test aircraft tread depth measurements were taken on each of the 17 tires evaluated. Based on these measurements an average tread life of 243 landings per tire was computed. Tire treads were relatively free from tread cuts and tears.

Two significant problems were air leakage through the sidewalls and progressive loss of folding quality. Folding quality tended to decrease with decreasing temperature, operation at high (50%) deflection, and long periods of inactivity when the aircraft was parked and did not fly.


DD FORM 1 JAN 64 1473

Unclassified

Security Classification

Unclassified
Security Classification

| 14. KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| TIRES: | | | | | | |
| Folding sidewall. | | | | | | |
| Expandable. | | | | | | |
| Inflatable. | | | | | | |
| Tread wear. | | | | | | |
| Run-flat capability. | | | | | | |
| Tire Wear: | | | | | | |
| Effects of braking. | | | | | | |
| Braking technique. | | | | | | |
| Normal, high deflection. | | | | | | |
| Tread cutting resistance. | | | | | | |
| Tire Performance. | | | | | | |
| Landing Gear Loads: | | | | | | |
| Landing impact shock. | | | | | | |
| Inflation/Deflation Subsystem. | | | | | | |

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through
_______________________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through
_______________________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through
_______________________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U)*

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

## FOREWORD

This report contains the results of an extensive flight test evaluation of 38.5/28 x 13.0-16, Type III, folding sidewall aircraft tires. The test was accomplished by the 4950th Test Wing, Aeronautical Systems Division, Air Force Systems Command at the request of the Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio.

Flight tests were conducted at Wright-Patterson Air Force Base during the period 17 March 1970 through 13 October 1971, and were directed by Mr. Larry A. Roberts, Test and Evaluation Branch, Test Engineering Division, 4950th Test Wing. Mr. Paul M. Wagner of the Mechanical Branch, Vehicle Equipment Division, Air Force Flight Dynamics Laboratory managed the overall program. The work was documented under project number 1369, "Mechanical Subsystems For Advanced Military Flight Vehicles."

The authors wish to acknowledge the support received during the program from personnel of the Air Force Flight Dynamics Laboratory and the 4950th Test Wing. The advice and assistance rendered by Carl P. Spier of Systems Research Laboratories, Inc., and J. F. Heimovics, Jr. and Charles E. Scherrer of the B. F. Goodrich Company were of great value to the program and are acknowledged with appreciation.

This manuscript was released by the authors in 1972 for publication as an ASD Technical Report.

This technical report has been reviewed and is approved.

ROBERT A. RUSHWORTH
Colonel, USAF
Commander, 4950th Test Wing

## ABSTRACT

A C-131B aircraft was equipped with modified, instrumented main landing gear assemblies, and type III (low pressure), folding sidewall, 38.5/28 x 13.0-16 aircraft tires were mounted on the main landing gear wheels. Takeoffs, landings and taxi runs were made at four different aircraft weights and at both 35% and 50% tire deflection. Braking intensity varied from light to heavy both with and without reverse pitch. Testing was conducted in all types of weather and the tires were exposed to operation on wet and snow covered taxiways and runways under a wide range of ambient temperatures.

The test aircraft was equipped with an air inflation/deflation system. The tires were deflated each time the landing gear was retracted and inflated each time it was extended. The tires could normally be deflated and folded within 15 seconds and reinflated within 10 seconds.

On two occasions during the program, rollouts were made with the test tires flat. On both occasions, one of which was the result of a blow out (caused by a locked brake), the tires demonstrated excellent runflat capability at ground speeds of up to approximately 100 knots. Directional control was good and no damage was sustained by the aircraft or the landing gear.

Operation at 50% tire deflection was demonstrated without serious degradation of carcass life, but with a significant increase in tread wear over that encountered while operating at 35% tire deflection. The higher deflection also degraded the folding quality of the tire more seriously.

The folding sidewall tires exhibited excellent tread wear qualities. Following removal from the test aircraft tread depth measurements were taken on each of the 17 tires evaluated. Based on these measurements, an average

tread life of 243 landings per tire was computed. Tire treads were relatively free from tread cuts and tears.

Some problem areas have been identified. Two of the most significant problems were air leakage through the sidewalls and progressive loss of folding quality. Folding quality tended to decrease with: a. Decreasing temperature. b. Operation at high (50%) deflection. c. Long periods of inactivity when the aircraft was parked and did not fly.

# INDEX

## LIST OF ILLUSTRATIONS

Figure | Page

# LIST OF TABLES

# INTRODUCTION

In recent years, the trend in the design of military aircraft has been toward increasing requirements for short takeoff and landing capability while operating from lower strength airfields or unpaved surfaces. At the same time, operating weights and cargo capacities have been increasing. The even higher cargo capacities of some future military transport aircraft designs will require multiple-landing-gear wheel assemblies with significantly larger tires, spaced farther apart, to provide the high flotation required. Therefore, in order to avoid reducing or impinging on the internal cargo volume of such aircraft, the landing gear storage cavities will be placed in pods outside the basic fuselage structure. Thus a dual penalty is incurred; additional structural weight is required for the pods and the added frontal area increases the overall airframe drag, as is the case with some of the larger military transport aircraft now in operational use.

In an effort to minimize these penalties, a series of programs were conducted by the Air Force Flight Dynamics Laboratory (AFFDL) which resulted in the development of the folding sidewall tire. The major advantage of using this type of tire is its reduced stowage volume. For future aircraft it offers the designer a means of reducing structural weight and airframe frontal area, both of which will improve aircraft range and performance. For existing aircraft this type of tire could be used on a retrofit basis to provide more "footprint" area and improve flotation.

The folding sidewall tire is capable of folding after takeoff for compact stowage and, upon gear extension, will expand again for normal usage. It provides many other operating benefits such as improved performance at high deflection, provision for increased tread depth, the ability to negotiate larger obstacles on the runway, in-flight pressure adjustment, and runflat capability.

In June 1968, this program was initiated to accomplish, for the first time, an actual flight test evaluation of the folding sidewall tire, and to confirm the functional capability of an airborne, rapid response inflation/deflation subsystem. This subsystem was designed and constructed by Systems Research Laboratories, Inc. (SRL) under contract F33615-68-C-1636 for use in the folding sidewall tire test program. The flight tests were conducted by the Aeronautical Systems Division's 4950th Test Wing at the request of the AFFDL. Both organizations are located at Wright-Patterson Air Force Base, Ohio.

A C-131B was selected as the test aircraft and the test tires were mounted on all four of the main landing gear wheels. These tires, designated 38.5/28X 13.0-16 (nominal dimensions of inflated diameter/folded diameter X inflated cross section - rim diameter), 12-ply rating, were developed by the B. F. Goodrich Company (BFG). The test tires, when inflated, were the same size as the standard tires used on the C-131B main landing gear.

## OBJECTIVES

The objectives of this flight test program were to:

a. Evaluate the performance of the folding sidewall tire under operational conditions at both normal (35%) and high (50%) deflection and in a runflat (folded) condition.

b. Determine the test tire's resistance to tread cutting. Due to the marked increase in tread circumference during inflation, the tread is under more tension than in a conventional tire. Thus, the test tires may be less susceptible to circumferential cuts and subsequent cut propagation, but more susceptible to lateral or radial cuts.

c. Measure the test tire's growth due to usage. This will provide information on the critical tire stowage dimensions and clearances.

d. Detect and identify any deficiencies not observed during laboratory dynamometer testing.

This report contains results from flight tests of the folding sidewall tire. The specific items discussed herein are primarily associated with the performance of the test tires and not with an evaluation of the inflation/deflation subsystem or associated instrumentation.

## TEST FACILITIES

### TEST AIRCRAFT

The test aircraft selected for this program was JC-131B S/N 53-7806 (Figure 1). The C-131B is a military version of the Convair 340, a twin-engine low wing monoplane. It is powered by reciprocating engines with full feathering propellers. Reverse pitch is also available for aerodynamic braking during landing roll out. The C-131B is equipped with two gas turbine driven auxiliary power units (APU'S) mounted externally in pods, one beneath each wing. One APU provides DC power and the other provides AC power for test equipment operation.

Installation of the test item required a number of modifications to the test aircraft. Structural modifications to the engine nacelles were required to mount the exhaust valve and actuator assemblies. Pneumatic and electrical lines were run out through the fuselage pressure envelope and through the wings to both engine nacelles. The main landing gear assemblies were modified to accomodate the inflation/deflation equipment and instrumentation. Orifices were inserted in the main landing gear actuator hydraulic lines to provide a retraction delay. An additional microswitch was installed on the landing gear handle in the cockpit to control the automatic inflation/deflation sequence. The compressors, reservoirs, controls, etc., were installed in the cabin. A detailed presentation of all the modifications to the test aircraft associated with this program may be found in Reference 1.

INFLATION/DEFLATION SUBSYSTEM

An airborne, rapid response inflation/deflation subsystem was installed in the test aircraft to accomplish inflation, deflation, and pressure adjustment of the test tires. Reference 1 contains detailed information on the design, fabrication, installation, and operation of this subsystem. A brief description of the subsystem and its functions follows.

The inflation/deflation subsystem consisted of compressors, high pressure reservoirs, relief valves, system controls and instruments, and associated plumbing. A schematic diagram is presented in Figure 2. From this diagram it may be seen that the subsystem was divided into two parts, one of which serviced the left main landing gear and the other the right main landing gear. The two halves were interconnected by a manually operated cross feed valve so that,

should a failure occur in one half of the subsystem, both main landing gear could be serviced by the other half.

Each half of the subsystem contained a four stage piston compressor, equipped with mechanical and chemical moisture separators. An 18-inch diameter, spherical steel pressure vessel was provided as a reserve air source and could be used to inflate the test tires on either main landing gear in case of a loss of pressure in the primary reservoirs.

In operation, the compressors pressurized the reservoirs to 2000 psia. For tire inflation, air passed from the reservoirs via two high pressure hoses which penetrated the fuselage pressure envelope, and ran through the inboard wing section on each side to the high pressure termination points on the control packages in each engine nacelle. A control package was mounted in each nacelle and was located directly aft of the main landing gear well. Each control package contained the valves and valve actuators which allowed air to enter or exhaust from the tires.

At the control package manifold, the high air pressure was reduced by passing the incoming air through a 0.147 inch diameter control orifice. The low pressure air downstream of the orifice passed through a swivel joint located in the landing gear well and into a 1 1/2-inch diameter air hose which ran down the back of the main landing gear (MLG) strut. The swivel joint pivoted during landing gear extension and retraction to reduce the stresses on the hose. The air passed through a manifold on the lower end of the hose and entered the hollow axle. Each end of the hollow axle was fitted with a rotating pressure seal which admitted air to the three-tube air manifold on each main landing gear wheel.

The three-tube manifold penetrated the wheel web and flange, conveying air into the tires. There were no valves or major restrictions between the control package manifold in the nacelle and the tires.

The comparative sizes of the folded and inflated tires are illustrated in Figure 3. In actual operation, the tires on each MLG were interconnected and inflated and deflated together. When the photo in Figure 3 was taken, however, the tires were isolated from each other for an air-retention test.

Airborne tire inflation could be accomplished by three different methods:

a. Automatic Mode: Inflation was initiated when the landing gear control lever was lowered to extend the gear. An inflation delay timer was built into the system so that inflation would not begin until the gear was clear of the wheel well. An elapsed time of one second, based on ground tests, was established as being sufficient for the inflation delay. A pressure switch stopped inflation when the tire pressure reached a preset value. In this mode, air was supplied from the primary reservoirs.

b. Manual (Electrical) Mode: Inflation was controlled by the test director, who actuated electrically controlled valves by means of switches on the system control panel (Figure 4). The primary reservoirs supplied the air for inflation in this mode, also.

c. Manual (Mechanical) Mode: In case of electrical failure, or loss of pressure from the primary reservoirs, inflation was accomplished from the reserve reservoir through mechanically controlled valves mounted on the system control panel.

In the automatic mode, with an initial reservoir pressure of 2000 psi, the system would inflate the tires to an operating pressure of 75 psi in less than 10 seconds from the time the landing gear control lever was lowered.

Tire deflation was accomplished through a large valve attached directly to the control package in each nacelle behind the MLG well. When the valve was opened, the air in the tires was vented through the axles, up the air hose attached to the back of the MLG strut, and dumped into an open cavity in the aft portion of the engine nacelle.

Deflation control could be either automatic or manual. In the automatic mode, the deflation valve opened when the landing gear control lever was raised to retract the gear. The hydraulic gear retraction system was modified by inserting an electrically operated valve in parallel with an orifice, into the hydraulic line to the gear actuator. When the gear lever was raised, the valve closed, thus forcing the hydraulic fluid to flow through the orifice. This flow restriction significantly reduced the gear retraction rate. The length of the retraction delay was controlled by an adjustable timer on the system control panel. When the preset delay time had elapsed, the valve opened, restoring normal flow. The initial timer setting, based on ground retraction tests, was 7 seconds. This was later changed to the maximum setting of 15 seconds when difficulties with tire folding were encountered. The purpose of the retraction delay was to allow sufficient time for the tires to deflate, fold, and recenter before they entered the wheel well. If the tires were deflected away from the MLG strut at the time the gear entered the wheel well, damage to the gear doors would result.

In the manual mode, deflation was accomplished by means of electrical switches located on the control panel. If an electrical power failure occurred, it was not possible to deflate the tires.

## CONTROL PANEL

The test system control panel in Figure 4 was used by the test director to monitor and control the extension/inflation and retraction/deflation functions of the system.

## WHEELS

The tube-type MLG wheel, currently used on the C-131B aircraft, was replaced with a modified, tubeless-type wheel for the purpose of this flight test program. The modified wheel (Goodyear P/N 9540977) was the tubeless equivalent of the tube-type 12.50-16 size main wheel (Goodyear P/N 9540912). The outer halves of the four main wheels were modified to provide adequate porting for a rapid inflation/deflation capability. Air passages and wheel penetrations are shown in Figure 5.

## TEST TIRES

### Tire Design

The tires evaluated during this test program were of the expandable/folding-sidewall design. The major design feature of the tire was that upon inflation, the sidewalls unfolded and the tread portion elastically expanded until the carcass assumed the shape of a standard aircraft tire. The inflated and folded (deflated) section profiles, and folding-sidewall tire nomenclature, are illustrated in Figure 6.

The test tires were capable of accommodating a large circumferential elongation of the tread region in the transition from the deflated to the inflated condition. This was made possible by a combination of the elasticity of the elastomer matrix in which the tire cord fabric was molded, and the pantographing action of the tire cords. The cords did not stretch nor were they subjected to any damaging stresses. On subsequent deflation, the carcass elastically contracted to collapse the tire to its initial smaller size, with the sidewalls refolding into the original molded shape.

## Tire Description

For the flight demonstration, folding sidewall tires were installed on the dual-wheeled main landing gear of the C-131B test aircraft. These tires, designated 38.5/28 X 13.0-16, 12-ply rating, were developed by the B. F. Goodrich Company. Specific design and construction details were distinct, B. F. Goodrich Co. responsibilities. General design and construction data are listed in Table I. Figure 7 shows a cutaway section of the test tire. For a baseline comparison, the folding sidewall tires, when inflated, were the same size as the standard tires used on the C-131B aircraft.

A section profile of the test tire is shown in Figure 8 for both the expanded shape, at 75 psi rated inflation pressure, and the folded shape. The folded diameter of the tire increases 35% when it is inflated to its rated pressure.

The test tires had the same cord type, carcass and tread compounds, utilized standard bead construction, and were within the specified weight limitation of the standard 12.50-16 size Type III (low pressure) aircraft tire.

Sidewall ribs were molded on the tire, above and below the sidewall fold, to provide a working wear surface between the upper and lower sidewalls to increase the life of the tire for runflat operation. During a runflat roll, as the tire tread contacts the landing surface, the upper and lower sidewalls of the folded tire make contact and slide together. In laboratory tests, a glossy appearance on the tire's external sidewall surfaces, after a runflat dynamometer evaluation, indicated that excessive frictional heating had occurred due to the sliding action between these two surfaces. Because of this frictional heating, and the resultant rapid deterioration of the rubber at these surfaces, the sidewall ribs were incorporated.

All flight test tires were inspected in the laboratory prior to being mounted on the test aircraft. This laboratory inspection was conducted to assure that the tires complied with the requirements of MIL-T-5041E, Reference 2. Inspection consisted of checking the dimensions, weight, balance, bead fit, folding quality, and air retention of the tires.

The test tire passed the qualification tests for the standard 12.50-16 Type III aircraft tire, and, in addition, its capabilities for runflat operation and operation at high (50%) tire deflections were demonstrated on the laboratory dynamometer.

In order that the folding sidewall tire perform optimally under runflat conditions, it was imperative that the tires' bead remain firmly seated against the wheel rim at all times. In initial dynamometer tests, unseating of the beads during runflat operation resulted in excessive vibration caused by tire distortion.

Due to these first unsuccessful runflat attempts, wherein the beads were unseated, various bead spacer designs were incorporated and evaluated in the laboratory. Based on these evaluations, the most promising bead spacer mechanism consisted of a combination of bands and spacers, as shown in Figure 9. This bead spacer was being evaluated in the laboratory during the early portion of the flight test program and so was not installed on the test aircraft with the first set of flight test tires. Detailed descriptions of the laboratory evaluation of the test tires and bead spacer mechanism are documented in Reference 3.

## INSTRUMENTATION

The test system was instrumented extensively. A magnetic tape recorder was installed in the cabin of the test aircraft and was used to record the following parameters:

a. R/H and L/H MLG Up-Down indication

b. R/H and L/H MLG strut pressure

c. R/H and L/H strut stroke

d. R/H and L/H pneumatic reservoir pressure

e. R/H and L/H MLG tire pressure

f. R/H and L/H MLG vertical force

g. R/H and L/H MLG outboard wheel speed

h. R/H and L/H MLG side force

i. R/H and L/H MLG drag force

j. Reserve reservoir pressure

k. R/H and L/H MLG vertical acceleration

l. Aircraft pitch attitude

m. Aircraft roll attitude

n. Airspeed

o. Time

p. Event mark

q. Voice from aircraft intercom and command radios

The aircraft was also equipped with a closed-circuit TV system. The TV camera was mounted beneath the aircraft, directly behind the nose landing gear well (Figure 10). It looked aft toward the main landing gear. A mirror image splitter was used to expand the portion of the camera frame occupied by the main landing gear. The TV monitor was mounted on a table adjacent to the system control panel where the test director could observe the test tires whenever the gear was extended (Figure 11). A video tape deck was also installed in the cabin and recordings of takeoffs, landings, gear extension and retraction, etc., were made.

Temperature indicators, which consisted of plastic encased window groups, were mounted within each tire. A strip of indicator windows ranging from 100°F to 300°F in 10°F increments were placed on a rubber strap around the circumference of the inner wheel half and held in place with a spring hoop (Figure 5). These indicators could be inspected only after dismounting the tire.

In addition to instrumentation installed in the test aircraft, a ground-based sink-speed camera was used to photograph test landings. The film was then used to determine aircraft vertical velocity at touchdown.

## TEST LOCATION

All test landings were accomplished at Wright-Patterson AFB, Ohio. Runway 23R-05L at Patterson Field was used for test missions 1 through 87. This runway was 12,600 feet long, 300 feet wide and constructed of concrete with a burlap-drag finish.

After mission 87, runway 23R-05L was closed for resurfacing with asphalt. Consequently, missions 88 through 115 utilized runway 23L-05R at Patterson Field. This runway was 6,000 feet long 150 feet wide and had just been resurfaced with asphalt.

The final high speed run-flat taxi test was accomplished on the recently reopened runway 23R-05L.

## TEST PROCEDURES

During the planning of the flight test phase of the program, a set of test conditions were selected and defined. A sequence of test missions was flown for each test condition and periodic measurements of tire wear were taken to determine the effect of a given test condition on tire tread life. These test flight sequences are summarized in Table II.

Each test condition was defined by specifying aircraft gross weight, type of landing, braking technique and percent tire deflection. Gross weight categories were light (41,300 to 42,600 lbs), medium (47,200 to 49,575 lbs) and heavy (51,171 to 56,665 lbs). All gross weight figures were based on the aircraft ramp weight before engine start.

Landings were classed as either braked-stop or touch-and-go. The category including braked-stop landings was rather large. Landings were made using the brakes to reduce the aircraft velocity to 30 knots after which a takeoff was made. Other landings were braked to a full stop on the runway and then a takeoff was made from the stopping point. Still other landings were made where the aircraft was brought to a complete stop using both the wheel brakes and reversed propellers. In some cases, especially at high gross weights, it was necessary to taxi back to the approach end of the runway for the next takeoff rather than taking off from the stopping point. This resulted in much greater taxi distances. All wear data for each category includes all the taxiing involved in making the specified number of takeoffs and landings.

Touch-and-go landings were made using normal approach and touch down procedures. After touch down, however, sufficient airspeed was maintained to permit directional control with the rudder but no wheel brakes were applied. Normal takeoff procedures were used to complete the takeoff.

Braking technique was identified as light, moderate, or heavy for each landing. The braking technique to be used for each landing was specified by the test director and adjusted as necessary to provide consistency between the various pilots who flew the test aircraft. If reverse thrust was used in conjunction with the wheel brakes, this fact was also recorded.

## TIRE DEFLECTION

The test tires, installed on the main landing gear were checked and adjusted to a specified inflation pressure at the beginning of each mission, before starting to taxi. During flight, prior to landing, the tires were reinflated

to the same specified pressure before each landing. This specified inflation pressure was that pressure required to maintain either 35% or 50% tire deflection for the existing aircraft gross weight (ramp weight at engine start). The proper inflation pressure was obtained from the load-deflection curves presented in Figure 12.

## TIRE MEASUREMENT PROCEDURES

Eight, equally-spaced, radial white stripes were painted on the sidewalls of the tires to provide position and spin-up references for both the video and sink-speed cameras. These stripes were also used to mark the locations at which tread-depth measurements would be taken. A depth gage was used to measure the depth of each of the 6 grooves in the tread at the specified locations on the tire. If the tires were unloaded (i.e., with the aircraft on jacks), measurements were taken for each groove at all 8 locations for a total of 8 readings per groove. With the tires under load, readings were taken for each groove at a minimum of 4 of the 8 locations to provide at least 4 readings per groove. The measurements for each groove were then averaged and the averages were recorded.

Tread-depth measurements were taken when the tire was new, at the end of each sequence of landings at a given test condition, periodically during such a sequence if sufficient landings were made, and when the tire was removed from the aircraft. The tire's outside diameter, both inflated and folded, was recorded when the tire was new, whenever the aircraft was on jacks for maintenance during the test, and at the time of tire removal. Tires were inspected periodically for any irregular tread wear, cuts and damage to the treads, sidewall or shoulder areas, cord fraying or breakage at the sidewall folds, and tire/wheel slippage.

TIRE REMOVAL CRITERIA

Tires were removed from the aircraft for internal inspection after exposure to adverse operational environments or after extended usage at conditions of heavy braking or high deflection. Under no circumstances was the continued usage of the tires to exceed that established in the removal criteria (Reference 5). As a minimum, the following removal criteria were established prior to flight tests:

1. Sidewall Cord Exposure - Cord exposure shall be on the outer layer of cord only. Tires will be removed if depth of exposure exceeds one actual cord body ply. Cord fraying is allowable. However, tires with evidence of cord breakage will be removed.

2. Wear Limits - Tires will be removed while approximately 1/32 inch of tread life is remaining. Tread life is defined as the measurement of tread material from the tread surface to the bottom of the tread groove.

3. Cut and Damage Limits - Tires will be removed when damage and cut-depth limits are exceeded as specified in Table 4-2, Inspection of Low-Speed Aircraft Tires, T.O. 4T-1-3, Reference 5. The following cut and damage limits were taken from Reference 5.

a) Less Than One Inch Long - Allowable depth below groove for cuts under one inch long at the first carcass ply is 7/32 inch.

b. More Than One Inch Long - Tires with cord body cuts or cord body damage over one inch long are not acceptable for continued use on the aircraft.

4. Tread Chunking Void Limits

a) The chunking void will not exceed the depth authorized for wear.

b) The width of any chunk void will not exceed one inch. The length will be limited such that tires with void areas over one square inch are not acceptable for continued usage.

c) The quantity of chunking voids will be limited to 10 per tire. Minor chipping less than 5/32 inch deep will not be regarded as chunking voids.

Typical Procedures Used During Test Missions: After starting engines, but prior to taxiing, the test director adjusted the tire inflation pressure to the proper value for the selected test condition. At this time, the TV camera and test instrumentation power were turned on. The aircraft was then taxied to the engine runup area adjacent to the active runway, and the mileage from the ramp to the runup apron was logged. During engine runup, instrumentation checks and calibrations were performed. Just before taking the active runway, the video and data tape recorders were turned on.

The "event" button was pressed at brake release and again at lift off. Tire pressures were monitored during the takeoff roll. When the tires had spun down and the wheels had come to a complete stop, the pilots were given clearance to raise the gear. Tire deflation and folding were observed in the TV monitor and, should improper folding occur, gear retraction was stopped and the gear re-extended.

After gear retraction was complete, the video recorder was turned off. Calibrations were run on the data tape recorder and then it, too, was turned off.

Prior to landing, both the video and data tape recorders were turned on shortly before gear extension and data tape calibrations were run. Gear extension and tire inflation were observed in the TV monitor. The test director pressed the "event" button at touchdown and also observed the tires on the TV

monitor during the landing roll to visually detect skids or locked brakes Another event mark was made when the aircraft came to a stop for full stop landings.

During each takeoff and landing, the pilots called out the touchdown and liftoff points on the runway as closely as possible by observing the runway markers and marker lights. The total ground roll distance was recorded along with any taxi distances required for full-stop taxi-back type landings. After the final landing, the aircraft taxied to the ramp and the distance from the runway to the parking area was recorded. Final calibrations were run and the instrumentation was turned off. In the parking lot, tire pressure was readjusted to 80 psig in most cases.

## TEST RESULTS AND DISCUSSION

The discussion of test results is divided into two sections. The first, titled Tire Performance, covers the wear, performance, and durability of the test tires. The second, titled Main Landing Gear Loads, deals with loads on the main landing gear during test landings. Data presented in this section was taken to determine if use of the test tires imposes unusual or excessive loads on the aircraft, especially during runflat operation.

### TIRE PERFORMANCE

Seventeen test tires were used during the test program and a total of 459 test landings were accomplished. Table III presents a test log listing all the tires tested. Tables X through XXVI present performance data on each individual tire.

Performance At Normal and High Deflections

Out of the total of 459 test landings, 349 landings were made at normal (35%) tire deflection and 110 landings were made at high (50%) tire deflection. Table IV summarizes the landings conducted at the normal and high tire deflections. Landings were categorized by type and by aircraft gross weight. Pilots commented that ground handling characteristics were good at both 35% and 50% tire deflections.

Flight test results showed that these tires could be repeatedly operated at 50% tire deflection. Although 50% deflection operation could be successfully accomplished, it had a considerably greater effect on the tire's tread life and folding quality than that which occurred when operating at 35% deflection. Operation at 50% deflection resulted in an increase in tire wear rate and a decrease in tire folding quality. None of the tires tested showed any signs of bead chafing, rim cutting, or tire-to-rim slippage after operating at 50% deflection.

For aircraft operation in and out of substandard landing sites, current practice is to obtain increased ground flotation capability through lowering the tire inflation pressure. In most cases, the tire pressure must be reduced so that the operating deflection is well beyond the normal range. On the basis of dynamometer testing (Reference 6), folding sidewall tires, especially in the smaller sizes, provide a noticeably increased carcass life over standard construction tires when operated at deflections in the 40% to 50% range. Results of this flight test program support the conclusion in Reference 6, that tires of the folding sidewall carcass construction are more durable, and

thus better suited for operation at high deflections than standard construction tires.

Runflat Capability

Should a test tire be punctured or damaged to the point where it loses air pressure, the sidewalls would normally fold inward, consequently preventing the wheel rim from cutting the tire during rollout. In this case the wheel rim rides on three layers of rubber, the tread and two sidewall layers, which prevent the rim from contacting the ground, thus avoiding the possibility of wheel failure. Runflat landings were successfully accomplished on the laboratory dynamometer (Reference 3) and this capability was explicitly demonstrated during the flight test program on two occasions described below.

Low Speed Runflat Rollout

Early in the program, an unscheduled tire runflat rollout occurred during the fourth landing of the 25th flight. The outboard wheel on the left MLG locked immediately when the brakes were applied. The tire skidded until a blowout occurred at an air speed of approximately 70 knots. When the tire (Serial Number N51-0035-11) failed, the automatic inflation subsystem cut in and depleted the reservoir pressure in trying to maintain pressure in both left MLG tires. As a result, the tires took several seconds to deflate which allowed for a gradual transition to the tires' folded position. It should be noted here that both tires on each MLG are interconnected and deflate together.

The transition from the inflated to the folded configuration was completed by the time the airspeed had decreased to approximately 50 knots, and the

remainder of the rollout was successfully completed with the left MLG tires in the folded configuration. (The wheel lock-up and subsequent tire blowout were attributed to an overheated brake). The flight crew felt an oscillation in yaw immediately after the tire failed, but the oscillation soon disappeared. Nose wheel steering was engaged when the failure occurred. The pilot stated that directional control was excellent throughout the rollout. Tires on the right MLG operated at normal inflation pressure.

This unscheduled rollout, from 50 knots to a safe stop, successfully demonstrated for the first time on an aircraft, the test tire's runflat potential. Table V outlines the sequence of events for this low speed runflat rollout. The condition of the outboard left MLG tire, after the runflat rollout, can be seen in Figures 13 and 14. Figure 15 shows the condition of the inboard left MLG tire (Serial Number N51-0035-14) after being inflated. Examination of this photograph shows that the sidewall ribs provided an excellent working wear surface between the upper and lower sidewalls, during the rollout. Consequently, very little sidewall damage was sustained.

High Speed Runflat Rollout

The second runflat occurrence, the most dramatic event of the program, was accomplished at the conclusion of the program during a high speed taxi run. The test tires were inflated to 55 psi. The test aircraft, at a gross weight of 40,700 lbs, was accelerated to 110 KIAS. The tires on both main landing gear were purposely deflated at approximately 96 knots ground speed. All four tires deflated evenly and folded on center, thus preventing the wheels from contacting the runway. The aircraft decelerated rapidly, even though wheel

brakes were not used. Reverse thrust was applied, initially, but only for approximately two seconds. Aside from the rapid deceleration, the only other significant deviation from normal rollout experience was a strong vibration from the main gear. Handling and steering the aircraft presented no problem. Shortly after tire deflation, the aircraft yawed slightly to the left and drifted laterally to the left an estimated 15 to 20 feet. The pilot attributed this to a fairly strong gust. The total runflat distance was approximately 3,500 feet. Table VI summarizes the sequence of events which occurred during this high speed runflat rollout.

The outboard tires on both main landing gear exhibited no evidence of failure or deficiency. However, when reinflated, these tires exhibited poor air retention qualities. The applicable specification, Reference 2, allows a maximum pressure loss of only 4 psi in a 24-hour period. Contained air losses for both outboard tires were greater than 16 psi in a 24-hour period. Figures 16 and 17 show the condition of the left main landing gear outboard tire, s/n 51-0035-17, upon reinflation. These figures also show the small amount of slippage which occurred between the tire and the wheel.

The inboard tires on both main gear had multiple tears and cuts in the sidewall area. These tears were incurred during the tire's transition from the inflated to the folded position. The left inboard tire, s/n N51-0035-2, had a kink in the inboard sidewall. This kink did not allow the tire to fold properly at this one spot on the sidewall. The condition of these two inboard tires explains the main landing gear vibration which was encountered during the rollout.

The cause of the folding difficulty experienced with the inboard tires can be attributed to the higher load distribution on these tires. The higher loads on the inboard tires are caused by changes in strut alignment which occur during a high speed taxi run. At high ground speeds, sufficient lift is generated to deflect the wings upward. This upward wing deflection causes the wing (engine nacelle) mounted main gear struts to cant outward, and, consequently, imposes higher loads on the inboard tires. Furthermore, this additional load is applied at the time the tires are to be folded. Additional factors which contribute to higher inboard tire loads are the crown in the runway and any initial static misalignment of the main gear struts which may exist.

The bead spacer mechanism, as described in the Test Facilities Section, under Tire Description, proved to be a workable device which performed satisfactorily. Initially, minor problems developed when the bead spacer mechanism came in contact with the tire's inner liner surface while the tire was folded. Early tire inspection revealed that considerable chafing had occurred after a number of folding cycles. This problem was quickly remedied by shortening the spacer tabs, thus preventing the tabs from contacting the inner liner when the tire was folded. A close-up of the chafed area on the inner liner of tire N51-0035-11 after the low speed runflat rollout is shown in Figure 18. This of course was the most severe chafing which occurred since the tire was operated in the runflat condition. After the tabs were shortened, no further problem was experienced with the use of the bead spacer mechanism. Flight test results showed that with the incorporation of this bead spacer mechanism the tire beads remained firmly seated against the wheel rim during both runflat rollouts.

In summary, both runflat rollouts successfully demonstrated the test tire's runflat capability. The folded tire prevented the wheels from contacting the runway, thus eliminating the hazard of any damage to the wheels, landing gear, or aircraft. All tires remained intact and the tires left no debris on the runway. The pilots had no difficulty controlling the aircraft during the rollouts (Reference 7). Towing of the aircraft from the taxiway into the hangar was accomplished on the folded tires without difficulty. The significance of these rollouts established that the runflat capability is available at any time in the tire's life cycle. It is important to note that the tires selected for the high speed rollout had been subjected to a significant amount of usage prior to the runflat evaluation. Table VII summarizes the previous usage on each of the high speed rollout tires.

## TREAD WEAR

Wear data on each individual tire is presented in Tables X through XXVI. Landing and mileage projections, based on individual tire wear rates, were computed and are listed in Table VIII.

As expected, the tread wear pattern was uneven with the greatest wear occurring at the center ribs. Therefore, all average wear rates mentioned in this report were based on the measurements taken at the center two tread grooves. The results of the tread wear measurements for five of the tires tested are shown in Figure 19. Tread wear trends which were based on the number of landings on the tire when removed from the aircraft are plotted in Figure 20.

Even though a limited number of tires were flight tested (a total of 17 were used), the data obtained during the program provides valuable insight in establishing wear trends and in determining the effects of various factors influencing the tread life of the tires. These trends and factors are discussed separately in the following paragraphs.

Wear Rate Computations

The wear-rate figures listed in the text of this report were computed in a variety of ways, but a sample calculation of one specific type will serve to illustrate the use of the various tables and their individual significance. As an example, the average tread wear rate for the test tires for flights 90 through 93 will be computed.

a. From Table II, flights 90-93 occurred during the period 15-20 July 1971.

b. From Table III, tires installed on the test aircraft during this period were:

N51-0035-20

N51-0035-25

N51-0025-15

N51-0025-2

c. From Table XXII the incremental wear for the 15-20 July, 1971 period on tire N51-0035-20 was 28 mils. From Table XXIII for tire N51-0035-25 the incremental wear was 23 mils. From Table XXIV for tire N51-0025-15 the incremental wear was 33 mils. From Table XXV for tire N51-0025-2 the incremental wear was 33 mils.

d. The total incremental wear for all four tires was 117 mils.

e. The average wear per tire was 117/4 = 29 mils.

## Wear Rate Variance in Tire's Life Cycle

Initially (i.e. when the tire was new), the tread wear rate measured in Mils (0.001 inch) per landing, was higher. Because of this, care was taken in comparing tires having less than 50 landings with those having considerably more landings. An example of this variance in tread wear rate during the tire's life cycle under identical flight test conditions can be seen in flight sequence 26 through 33 (Table II). Two new tires were installed on the left MLG prior to flight 26 (Table III). At this time, the tires on the right MLG had 35 landings each. Thirty landings were made in this sequence which resulted in the wear rate of the left MLG tires (2.13 Mils Per Landing) being more than twice that of the right tires (1.00 Mil Per Landing).

Another example of the initial high wear rate is the comparison of the average wear rate, in Mils per landing, between tires removed early and those that were removed after more than 140 landings. This comparison is displayed graphically in Figure 20.

Some reasons for the higher wear rate at the beginning of the tire's life cycle are a possible overcure on the outside surface during tire curing and a skin pull-away effect which may occur when a tire is removed from the mold. Also, the rate of wear will decrease as the tread is removed because the tread becomes stiffer as the working surface comes closer to the carcass.

## Effect of Aircraft Gross Weight

Increases in aircraft gross weight, or an increase in tire inflation pressures required to maintain 35 percent or 50 percent tire deflection, resulted in higher

tread wear rates. Figures 21 and 22 show increasing tread wear rates for corresponding increases in tire inflation pressures at both 35% and 50% tire deflections. Data presented in Figure 22 were obtained on tires with 50 or more landings under generally identical conditions of light to moderate braking with reverse thrust.

## Effect of Tire Deflection

Braked-stop type landings, operating at 50 percent deflection, resulted in an increase in tread wear rates. Tread-depth measurements at the completion of the braked-stop landings showed average wear rates of 1.88 and 1.42 mils per landing at 50 percent and 35 percent tire deflections, respectively, for operation at the heavy aircraft gross weights. Braked-stop landings at the light aircraft gross weights resulted in average wear rates of 1.16 and 1.00 mils per landing at the 50% and 35% tire deflections, respectively. Based on these braked-stop averages, operation at the higher deflection increases the tire's tread wear rate by 32% and 16% over normal deflection operation at the heavy and light aircraft gross weights, respectively.

However, for the touch-and-go type landings, operating at the higher tire deflection and at the same aircraft gross weight resulted in a decrease in the tread wear rates. At both heavy and light aircraft gross weights, operating at 50 percent tire deflection during touch-and-go type landings reduced the tread wear rates (mils per landing) by 14 to 23 percent. Figures 21 and 22 show the tread wear rates at 50% and 35% tire deflection when operating at various aircraft gross weights.

Effect of Wheel Braking

The effect of braking on the tire's tread life is significant and can be determined by comparing the tire wear data from the braked-stop type landings with that of the touch-and-go type landings (unbraked wheels). At 50 percent tire deflection operation, the average wear rates (mils per landing) on a braked wheel tire were 200% higher than those obtained on a free rolling tire. At 35% deflection, the wear rates for braked-stop landings shown in Figure 21 increased by 15 to 34 percent over touch-and-go type landings shown in Figure 22 at equivalent tire inflation pressures.

Though the caption for Figure 22 indicates that it contains data for touch-and-go landings only, this is not strictly true. Physical measurements of tire wear could be made only at the end of a test mission and each mission did, of necessity, end with a full-stop landing. Consequently, a small percentage of the data present in this figure does represent braked-stop landings, but this does not effect the tread wear rate values significantly. Furthermore, wear rate values obtained in these flight sequences can be adjusted to reflect only the touch-and-go landings. This adjusted wear rate value for a touch-and-go (T&G) landing flight sequence can be computed as follows:

$$\text{Wear/T\&G Landing} = \frac{W_{fs} - N_b\,(W/N)_{avg}}{N_{tg}}$$

Where:

$W_{fs}$ = Average tread wear accrued during the flight sequence under consideration.

$N_b$ = Number of braked-stop landings which occurred during the flight sequence under consideration.

$N_{tg}$ = Number of touch-and-go landings which occurred during the flight sequence under consideration.

$(W/N)_{avg}$ = The average Braked-Stop Wear Rate at the test inflation pressure used during the flight sequence under consideration, obtained from Figure 21.

As an example, flight sequence 90 through 93 (Table II) had 35 touch-and-go landings and 4 braked-stop landings. The average tread wear obtained on the four tires during this flight sequence was 0.029 inch or 29 mils for an inflation pressure of 60 psi. The corresponding average tread wear rate at this inflation pressure for braked-stop landings is 1.00 mil per landing. Using this data in the above equation, the wear rate per touch-and-go landing for flight sequences 90 through 93 is now adjusted to a value of 0.71 compared to 0.75 mil per landing as plotted in Figure 22. Using this adjusted wear rate value, the equivalent number of touch-and-go landings that would be expected per braked-stop landing, can also be determined. For a light aircraft gross weight, and operating at 35% tire deflection, one braked-stop landing on the test aircraft is equivalent to: 1.00 mil/braked-stop landing divided by 0.71 mil/touch-and-go landing, or 1.4 touch-and-go landings. For a heavy aircraft gross weight and operating at 50% tire deflection, one braked-stop landing is equivalent to: 1.88 mils/braked-stop landing divided by 0.81 mil/touch-and-go landing, or 2.3 touch-and-go landings.

## Wet Surface Conditions

Testing on surfaces with various degrees of wetness was not an intentional part of the flight test plan. However, during the course of the flight test program, a number of landings were conducted on wet surfaces. The degree of wetness consisted of either damp, intermittent patches of standing water, or flooded surface condition.

One notable brake-stop on a flooded runway resulted in an adverse tire-surface phenomenon called "reverted rubber skid". This phenomenon is named for the appearance of the tread after this type of skid has occurred. The contact of the skidding tire with the wet runway surface provides enough heat to turn the water trapped in the footprint into steam. The resulting temperatures become high enough to cause the rubber in the tire footprint area to revert to the uncured state, by heating it to the melting point. A reverted rubber skid will frequently occur during heavy braking on flooded runways, especially when the aircraft is not equipped with an antiskid system.

The test aircraft was not equipped with an antiskid system and the reverted rubber skid occurred during the third, brake-stop landing of Flight 17. All four main landing gear tires exhibited patches of reverted rubber and approximately 1/32 inch of tread was removed from each tire in the skid contact area. However, the tires were not seriously damaged, and flight testing was continued without a tire change. Figure 23 shows a close-up of the contact patch of tire s/n N51-0035-14. This test demonstrated that the stretched tread on a folding sidewall tire will withstand a reverted rubber skid.

Based on the wear data available, the influence of a number of factors concerning tread wear could not be quantitatively determined. These factors include such effects as outside diameter differences between paired tires, brake drag, braking technique (light, moderate, or heavy braking), and reverse pitch. Because of the braking problems encountered during the initial landings, the heavy braking technique was discountinued and use of reverse pitch was required on all landings after flight 25. In general, heavy braking without

the use of reverse pitch resulted in uneven wear, causing either a flat spot or a series of flat spots circumferentially around the tire tread.

Summary of Tread-Wear Results

Results showed that the flight test tires exhibited excellent tread wear qualities. Based on the remaining tread skid depth of the 17 tires evaluated, the average tread life was projected to 243 landings per tire. Average wear rates were 1.41 mils per landing or 0.73 mil per mile. The average mileage projected to 469 miles per tire.

CUT RESISTANCE

Due to the marked increase in tread circumference during inflation of a folding sidewall tire, the tread is under more tension than a conventional tire tread. Thus, prior to the flight test program, it was felt that this foldable-expandable type tire might be more susceptible to cutting and subsequent cut growth. If this was the case, any cuts in the stretched tread caused by foreign object damage, would progress rapidly and lead to an earlier than normal tire removal. However, with one exception, all tires flight tested were relatively free from tread cuts and tears. The one exception was a lateral cut which occurred on tire number N51-0035-16. This cut was first noticed after the 48th landing on the tire. The lateral cut in the tread crown, shown in Figure 24, was 2 1/2 inches long by 5/32 inch deep and was attributed to foreign object damage. There was no measurable cut progression when the tire was removed from the aircraft after 56 landings.

Significance of these results show that the stretched tread offers sufficient cut and tear resistance, and that when damage does occur, subsequent

cut propagation is negligible.

FOLDING QUALITY

All tires, when new, displayed a slight lateral shift during the folding and expanding procedure. For example, one sidewall would start to fold before the other, causing the tread portion of the tire to shift or "kick" axially outboard or inboard before returning to a symmetrical fold. Also, this shifting occurred repeatedly in a predictable direction on new tires. Because of this predictable "kick" direction, new tires were installed on the aircraft and so mounted that the lateral shifting was toward the landing gear strut. This precaution was taken to insure that the folding tire would always pass through the gear well entrances without causing any interference. In addition to the precaution taken in mounting the tires on the aircraft with respect to the "kick" direction, the following procedures were also incorporated:

1. The main landing gear retraction time-delay, based on functional ground tests, was initially set at 7 seconds for the flight tests.

2. In-flight braking was applied to bring the wheels to a full stop prior to deflation and retraction. Folding of the non-rotating tire was accelerated without the influence of centrifugal force on the tire. Also, it was easier for the test director to determine the "kick" direction when viewing a non-rotating tire on the TV monitor.

Results of this test program showed that the folding quality of each test tire decreased with usage. This was in agreement with the results of the laboratory evaluation. However, the laboratory evaluation did not indicate

that the "kick" direction would change with usage. Flight test results showed that, after extensive usage, the "kick" direction was erratic and unpredictable. For example, in many instances after extensive usage, the tire would shift toward the strut during the unfolding (inflation) process as expected; but at various times during deflation would "kick" away from the strut before returning to a folded position. When erratic folding performance occurred, the retraction time delay was increased to its maximum setting of 15 seconds. In other instances, the manual deflation mode was used. In one flight sequence where folding quality was questionable, the tires were reinflated prior to retraction, and then retracted inflated as an added precaution. After this flight sequence, an inflation-deflation check of these tires with the aircraft on jacks showed that the "kick" direction had reversed on three of the tires. Also, the time it took for 2 of the 3 tires to center at the proper symmetrical fold had approximately doubled. The third tire, number N51-0025-2, was forced back to center with much effort. The change in "kick" direction and the poor folding quality exhibited by these tires can be attributed to operating the tires at 50% deflection. This set of tires had been subjected to a high percentage of landings at 50% deflection. For example, 46 percent or 110 landings were conducted on tire number N51-0035-25 at 50% deflection. Or, in the case of the tire (number N51-0025-2) which had to be forced back into a symmetrical fold, 40 percent or 74 landings were conducted at 50% deflection.

The tire's folding quality noticeably decreased when tires were folded inflight after being inflated over long periods of aircraft parking. The cause of this folding problem was not evident during the laboratory evaluation since the tire's retention of folding quality was not evaluated after extended inflation

on the order of weeks. When a tire had not been folded for several days, its deflation time was longer than the fold down time experienced after only a short period of inflation. This was evident on flights where a number of landings/inflations and takeoffs/deflation were made in a relatively short period of time. In Figures 25 and 26, a comparison between the first and fourth deflation on a test mission reflects what influence an extended stretch/inflation period had on the tire's deflation time. Short time intervals between tire foldings allowed the tires to relax and to improve or restore their folding "memories".

An air injection test was conducted in the laboratory on four tires which had been removed from the aircraft. These tires were removed because their shift direction was erratic and their leakage rates had been high during long periods of inactivity at low ambient temperatures. The air injection test consisted of inserting an air needle into the tire's bead area. The air needle was operated at a controlled pressure of 125 psi for a minimum of 15 minutes. At the end of the 15 minutes, the needle was removed and a leak check was conducted which consisted of applying suds to the bead region and inner surface of the tire. The following results were obtained on the four tires which are listed in order of increasing air leakage observed:

(1) Tire No N51-0035-17 (Right Outboard Position on MLG). - Air was leaking at the bead toe sockets and at the sharp edges of the bead toe flat spots. This tire had been subjected to 179 flight landings.

(2) Tire No N51-0035-9 (Right Inboard Position on MLG). - A leak was evident at one location at the inner liner surface. This was attributed to cord shrinkage at this location. This tire had been subjected to 179 flight landings.

(3) Tire No N51-0035-12 (Left Outboard Position on MLG). - Air was leaking at the bead toe sockets, bead toe, bead face, and at the corners of the toe flat spots. This tire had been subjected to 144 flight landings.

(4) Tire No N51-0035-2 (Left Inboard Position on MLG). - Air was leaking at the same locations as tire number N51-0035-12; but leaking was more excessive. This tire had been subjected to 144 flight landings.

Based on the results of the air injection tests, the following was concluded:

a. The bead spacer mechanism was not the cause of the tire's poor air retention.

b. Prior to the air injection test, it was suspected that the liner stock might change permeability when stretched, thereby allowing greater than normal diffusion of air through the carcass. However, there was no evidence of leakage through the inner liner, thus liner permeability was not a factor.

c. Severity of leakage observed in the air injection test compares with the results obtained from the tire retention test conducted on the aircraft. Also, the greater the leakage rate, the worse the folding quality displayed by the tires.

## OPERATIONAL TEMPERATURES

Temperature indicators, as described in the discussion of Instrumentation under Test Facilities, were mounted within each tire cavity to obtain the peak contained air temperature endured by the tire. Temperature-sensitive materials within each labeled window would turn from white to black upon exposure to a given temperature for approximately two minutes. Inspection of the indicators removed from the tires which had been operated at 35% tire deflection revealed peak contained air temperatures on the order of 160° to 180°F. Tires which had undergone numerous runs at 50% deflection had peak contained air temperature

values of 230°F. The peak contained air temperature values obtained for 35% and 50% deflection operation were in agreement with the laboratory results of Reference 3.

DIMENSIONAL GROWTH

Usage growth data are summarized in Table IX on tires which had more than 50 landings. The symbols and subscripts used in this table are identical to those used in the Tire and Rim Association Yearbook (Reference 8) with the exception of additional subscripts for the purpose of identifying an expanded or folded condition. The following symbols, with subscripts, apply to this subsection:

$D$ Rim Ledge Diameter

$D_{oe}$ Maximum Expanded Outside Diameter (New, After 12-Hour Minimum Stretch and at Rated Inflation Pressure)

$D_{ge}$ Maximum Expanded Grown Outside Diameter (Used, After Completion of Flight Testing and at Rated Inflation Pressure)

$D_{of}$ Maximum Folded Outside Diameter (New, After 12-Hour Minimum Stretch and in a Non-Inflated Condition)

$D_{gf}$ Maximum Folded Grown Outside Diameter (Used, After Completion of Flight Testing and in a Non-Inflated Condition)

$H_e$ Maximum Expanded Section Height (New Tire)

$H_f$ Maximum Folded Section Height (New Tire)

$W_e$ Maximum Expanded Cross-Sectional Width (New Tire)

$W_f$ Maximum Folded Cross-Sectional Width (New Tire)

$W_{ge}$ Maximum Expanded Grown Sectional Width (Used Tire)

$W_{gf}$ Maximum Folded Grown Sectional Width (Used Tire)

$G_{he}$ Expanded Height Growth Factor

$G_{hf}$ Folded Height Growth Factor

$G_{we}$ Expanded Width Growth Factor

$G_{wf}$ Folded Width Growth Factor

The maximum expanded section height for the folding sidewall tire in the new condition is given by:

$$H_e = \frac{D_{oe}-D}{2}$$

The maximum folded section height for the folding sidewall tire in the new condition is given by:

$$H_f = \frac{D_{of}-D}{2}$$

The growth factors for the folding sidewall tire's expanded height, $G_{he}$ and expanded width, $G_{we}$, are given by:

$$G_{he} = \frac{D_{ge}-D}{H_e} \quad ; \quad G_{we} = \frac{W_{ge}}{W_e}$$

The growth factors for the folding sidewall tire's folded height, $G_{hf}$, and folded width, $G_{wf}$, are given by:

$$G_{hf} = \frac{D_{gf}-D}{H_f} \quad ; \quad G_{wf} = \frac{W_{gf}}{W_f}$$

Calculated growth factors presented in Table IX on tires in the inflated (expanded) condition are in line with the growth factors presented by the Tire and Rim Association (Reference 8). The appropriate tire service growth factor listed in this reference for a Type III (low pressure) aircraft tire is 1.04 and 2.08 for the section width and height respectively. Although dimensions of folding sidewall tires in the inflated condition will not be required in the determination of storage compartment - folded tire clearances, the tire's inflated service growth serves a good comparison with the existing growth factors for

standard tires. The tire's folded width growth factor ($G_{wf}$) is within the design allowance as specified in Reference 8. The folded section width, as in the case of this flight tested tire, is not a critical dimension, since it generally does not exceed the wheel width dimension.

However, the tire's folded outside diameter is the critical dimension when compensated for growth during service. This dimension will determine the allowable clearance between the tire and the adjacent parts of the stowage compartment. From folded diameter dimensions, the height growth factor ($G_{hf}$) obtained on flight tested tires is 8 percent higher than the 2.08 value recommended in Reference 8. Therefore, when compensating for service growth on folded tires of like size, the existing Type III (low pressure) height growth should be increased by 8 percent.

TIRE REMOVAL

As shown in Table VIII, the average wear rate for the 17 tires tested varied from 1.11 to 3.00 mils per landing. The higher wear rates (1.80 to 3.00 mils per landing) were obtained on the eight tires that were considered as early removals (tires with 56 or less landings). Because of an early removal from the aircraft, the tire's wear rate is high as previously discussed. The following paragraphs cite the history and causes of early removal of these eight tires.

The initial set of tires; number N51-0023-5, N51-0023-7, N51-0023-18, and N51-0023-19; were removed from the aircraft after 41 landings. Moderate to heavy braking was used during 75 percent of the brake-stops. Of the total brake-stops, 68 percent were conducted without reverse thrust, thus subjecting

the first set of tires to abnormal braking conditions. These tires were removed from the aircraft after the outboard tire on the right main landing gear went into a full skid during the brake-stop on the 15th flight. The flight test plan called for a heavy brake-stop condition. The skid caused a flat spot on the tire, removing all of the tread at that spot. This tire, shown in Figure 27, had to be replaced since the damage exceeded the limits set forth in the tire removal criteria for this test. The full skid was attributed to excessive braking by the pilot. Several flatspots were also evident on the other three tires because of the heavy brake-stop conditions. It is noted that these tires were installed without a bead spacer mechanism. Also, tire-to-rim slippage was incurred due to the heavy braking when operating at 35 percent deflection. Tire-to-rim slippage varied on each tire and ranged from 1/4 to 5 inches as measured at the rim.

Tire number N51-0035-11 was removed because of a blowout which occurred after the fourth touchdown of the 25th flight. Tire number N51-0035-14, paired with tire N51-0035-11 on the left main landing gear, was also removed because of the subsequent rollout under runflat conditions.

Tire number N51-0035-26 was removed after 10 landings because of a sidewall blister. This was the only tire in the program that was removed from the aircraft because of a cord ply separation.

An external surface deficiency, that of the rubber splitting and exposing the outer layer of cord in the sidewall area, occurred on a number of tires. This problem was encountered early with tire number N51-0035-16, resulting in

its removal after 56 landings. Figure 28 shows that the split occurred on tire number N51-0035-16 just below the upper sidewall rib, exposing the outer layer of cord. This problem was not considered to be critical, since cord exposure never progressed into the inner plys nor at any time was cord breakage at the outer ply experienced. However, this sidewall split presented a weak spot in the tire, and any "wicking" of air through the tire would eventually vent out at this location. After extended usage, the tire's air retention and folding quality were degraded somewhat by this cord exposure. This problem can be reduced by the addition of rubber stock at the sidewall region during the tire's building operation.

The remaining 9 tires were removed from the aircraft after accumulating a considerable amount of service life. The number of landings obtained on these tires ranged from 78 to 239 landings with an average of 171 landings per tire. Reasons for removal are as follows:

Tire numbers N51-0035-9 and N51-0035-17 (179 landings each) and tire numbers N51-0035-2 and N51-0035-12 (144 landings each) were removed after flight 64. Two of these tires, numbers N51-0035-9 (Right Inboard Position) and N51-0035-2 (Left Inboard Position) had changed their shift direction and would fold away from the strut centerline. Since the shift direction was erratic on at least one tire of each MLG, as a precaution, the complete set of main tires were removed because of flights scheduled for operation at 50% deflection. Three of these tires; numbers N51-0035-2, N51-0035-12 and N51-0035-17; were later used in the high speed runflat evaluation.

Tire number N51-0035-20 was removed after 161 landings. As shown in Figure 29, this tire experienced a sidewall surface split identical to that of tire number N51-0035-16.

At the conclusion of flight testing under conditions at normal and high deflections, tire numbers N51-0035-25, N51-0025-15, and N51-0025-2 were removed from the aircraft. These tires were replaced with tires that had less usage and exhibited better folding characteristics as required for the high speed runflat rollout.

Tire number N51-0025-14, with only 78 landings and in excellent condition, was left on the aircraft for the high speed runflat rollout.

Figure 30 shows the method used to number the tire tread grooves for the purpose of taking wear measurements. The tread groove numbers in this figure correspond to the numbers at the top of the "Tread Groove Depth Reading" columns of Tables X through XXVI.

## CONCLUDING REMARKS ON TIRE PERFORMANCE

The test program successfully demonstrated the inherent safety, durability and runflat capability of the folding sidewall tire. For example:

a. The test tires exhibited excellent tread wear qualities. A computation of the projected average tread life per tire, based on the remaining tread depth of the 17 tires evaluated, yielded 243 landings per tire. The average number of actual landings per tire, based on a total of 459 landings, was 108 landings.

b. The stretched tread offered adequate cut and tear resistance during the test, and when damage did occur, subsequent cut propagation was neglible.

c. The test tire's capability to operate at 50% tire deflection without a serious reduction of carcass life, was repeatedly demonstrated. Neither bead chaffing nor tire-to-rim slippage were encountered while operating at 50% tire

deflection. Of the 459 total landings, 110 landings were made at 50% tire deflection.

d. Operation at 50% tire deflection did result in an increase in tread wear rate and a decrease in tire folding quality.

e. Tire folding quality was also adversely affected by long periods of inactivity during which the aircraft was parked on the ramp. When the aircraft was grounded for several days, the first gear retraction, following such an inactive interval, resulted in slow and erratic tire folding performance. Folding performance improved, however, after a number of inflation/deflation cycles.

f. The runflat capability of the test tires was demonstrated on two occasions with satisfactory results. The tires folded properly and prevented the wheels from contacting the ground. No aircraft damage was sustained and the tires did not leave any debris on the runway. Aircraft directional control was good and ground handling characteristics were generally satisfactory.

g. The bead spacer mechanism installed in the test tires performed satisfactorily and kept the bead seated firmly against the wheel rim during runflat operation.

h. Performance of the inflation/deflation system was generally satisfactory. The test tires could be inflated to a specified pressure within 10 seconds. Deflation and folding could be accomplished within 15 seconds.

Some improvements in tire design are required to enhance tire folding quality and air retention, and to eliminate cord exposure in the region of the sidewall fold. These three problems are, to some extent, interrelated.

After extended tire usage, and progressive increases in sidewall cord exposure in the area of the fold, the tire's air retention is degraded and most of the air is vented through these split areas in the sidewall. As a result of increased quantities of air passing through the carcass, the tire's folding quality is degraded.

The cord exposure problem can be reduced or eliminated by the addition of rubber stock to the sidewall area during fabrication of the tire. This will contribute to improvements in air retention also. Other methods of enhancing tire air retention include:

a. An increase in the length of the 'own plys and finishing strips to provide better sealing in the bead region.

b. Rounding off the sharp edges of the bead retainer "bull" ring (part of the tire mold equipment) to reduce leakage at the corners of the bead toe flat spots.

c. Elimination of the bead toe pin sockets, which are no longer required for the type of bead spacer mechanism being used.

An improvement in the design of the inflation/deflation subsystem should also be accomplished to enhance future evaluations. An air ejector device should be added to draw air out of the test tires during the deflation cycle. This would speed up the deflation process and would also be useful in improving tire folding performance.

MAIN LANDING GEAR LOADS

Data Reduction Procedures

Flight data was processed and provided for analysis in the form of tabulations of the various parameters versus time. A very large quantity of data was taken and many parameters were recorded, but constraints on manpower and time made it necessary to investigate only a few of these parameters. The main landing gear loads along the vertical and drag axes were selected as especially significant.

Peak loads were selected from the data tabulations for each landing for both the vertical and drag axes. The tabulation sample rate for test landings was 16 samples per second. These peak loads were divided into two general categories: "impact" and "overall".

a. An "impact" peak load was defined as the greatest load occurring within one second of wheel impact. When there were multiple impacts (i.e. when the aircraft bounced) each impact was inspected individually and the largest peak load fitting the foregoing definition was recorded.

b. An "overall" peak load was defined as the greatest load encountered during the entire landing and rollout. Thus, it was possible for the impact and overall loads to be identical. This was frequently true in the case of touch-and-go landings where the loads at impact were often the greatest loads experienced during the landing.

Two sets of data tabulations were provided for each test mission; one for the left and one for the right main landing gear, since each main landing gear

was instrumented separately. Consequently, for each landing a single impact peak load and a single overall peak load were recorded for each main landing gear for both the vertical and drag axes.

The peak load readings were divided into groups based on aircraft ramp weight before takeoff, percent tire deflection, and type of landing. For the purpose of this analysis it was necessary to divide the "heavy" weight category mentioned in the Test Procedures Section into two separate categories of 51,000 lbs and 56,000 lbs. Thus, test landings were made in four weight ranges which are designated as 42,000 lbs, 48,000 lbs, 51,000 lbs, and 56,000 lbs. These weights were actually the computed total aircraft weight as the aircraft stood on the ramp before starting engines. No attempt was made to adjust the aircraft weight downward for each successive landing. All landings made during a mission were grouped under the computed aircraft ramp weight before takeoff. (Hereafter, the term "gross weight" refers to the computed ramp weight).

Tire deflections used during the test were 35% (normal) and 50% (high). Types of landings made were full-stop and touch-and-go. For the full-stop landings, wheel brakes and, in some instances, thrust reversal were used to bring the aircraft to a stop on the runway. In the case of the touch-and-go landings, no braking was used and sufficient airspeed was maintained during the ground roll to preserve rudder effectiveness.

It was not possible to use data from all of the 459 test landings in this analysis. Test instrumentation problems, recorder malfunctions and similar occurrences rendered some of the data unusable. The various landing conditions

and the number of usable landings made at each condition are listed in Table XXVII.

Vertical Peak Loads

Description Of Figures: Figures 31 through 35 show the frequency of occurrence of vertical peak loads for various combinations of gross weight and tire deflection. They depict the probability of equalling or exceeding a given vertical peak load for a specific landing condition, based on experience gained during this test program. A line is drawn at 0.6 vertical design load for reference. (The choice of 0.6 vertical design load rather than 0.4, for instance, was arbitrary). Table XXVIII contains the data from which the frequencies of occurrence plotted in Figures 31 through 35 were computed.

*Expected Trends:* *From engineering theory and experience, one would expect the following trends to be present in the data:*

*a. Impact Vertical Peak Loads:*

*(1) The impact vertical peak load versus frequency of occurrence curves (Figures 31 and 32) should be ranked by aircraft gross weight so that the curve for 56,000 lbs would lie above the curve for 51,000 lbs which would lie above the curve for 48,000 lbs, etc.*

*(2) For a given gross weight, the impact vertical peak loads for 35% tire deflection should be greater than those for 50% deflection (Figure 33). At 50% deflection the tires were "softer" (inflation pressure was lower) than at 35% deflection and, therefore, might be expected to absorb more of the impact energy, thus reducing the load transmitted to the gear.*

*b. Overall Vertical Peak Loads: One would expect the overall vertical peak loads (Figures 34 and 35) to be ranked by aircraft gross weight in the same manner as the impact vertical peak loads.*

Modifying Factors

Since there is usually a perceptible difference between "expected trends" and actual test results it is in order to discuss those particular factors (in so far as they are known) which generate the gaps between expectation and actuality.

a. Effect Of Touch-And-Go Landings On Overall Vertical Peak Loads: The ratio of full-stop landings to touch-and-go landings, for a given weight and tire deflection, has a marked effect on the shape of the overall vertical peak load curves. For a touch-and-go landing the overall and impact vertical peak loads are usually equal. This is due to the fact that sufficient airspeed is maintained during the ground roll to generate lift on the wings and the full weight of the aircraft is never applied to the gear. The net effect on the overall vertical peak load curve is:

(1) The upper part of the curve is shifted to the left and downward.

(2) The "knee" of the curve is flattened, somewhat, and breaks less abruptly.

b. Pilot Technique: This item is usually the catch-all for inconsistencies in the data which cannot otherwise be explained. However, pilot technique was definitely a major factor in the acquisition of test data for this project. It should be stated at this point, that all landings were made using standard, handbook procedures (Reference 4).

(1) At low gross weights (i.e. 42,000 lbs), vertical velocity at touchdown was not critical and, while the pilots always attempted to make smooth landings, the consequences of making a "firm" one were not serious.

(2) At high gross weights, however, "firm" landings became a matter of concern. At 51,000 lbs gross weight, and above, the attitude of the pilots was one of great caution since the possibility of "dropping" the aircraft was increased and a hard landing could cause structural damage. This variation of

pilot vigilance with increasing gross weight undoubtedly had an effect on the magnitude of the impact vertical peak loads, and tended to prevent them from increasing at a rate proportional to the weight increase.

(3) The major variable which was affected by pilot technique was vertical velocity at touchdown. Small variations in this parameter can cause large differences in impact loads. For instance, the vertical component of the kinetic energy of the aircraft at touchdown, for a given gross weight, was more than twice as great at 3 ft/sec vertical velocity as it was at 2 ft/sec.

Discussion of Curves

a. Impact Vertical Peak Load

(1) 35% Tire Deflection (Figure 31): The data points for both the 42,000 lb and 48,000 lb landings lie very close together and do not conform to "expectations". The data show that the probability of experiencing an impact vertical peak load in excess of 13,000 lbs is greater for a landing in a 42,000 lb aircraft than it is for one in a 48,000 lb aircraft. One would expect the opposite to be true. The most probable reason for this discrepancy is pilot technique. Increased pilot caution at 48,000 lbs gross weight may have resulted in reduced vertical velocity at touchdown. Comparison of the 55,000 lb landing data with that for 42,000 lbs and 48,000 lbs certainly does agree with "expectations", although the separation between these plots is very large. In this case, it is possible that the increase in aircraft mass, and the greater inertia associated therewith, may have resulted in increased vertical velocity at touchdown. No impact vertical peak loads in excess of 0.6 vertical design load were recorded at 35% deflection. The maximum impact vertical peak load recorded during the program occurred on the third landing of flight 98 (42,000 lbs, 35% deflection). Figure 36 presents

a time history of several parameters recorded on this landing. The computed vertical velocity at touchdown was 5.34 ft/sec.

(2) 50% Tire Deflection (Figure 32): The data for the 42,000 lb and 51,000 lb landings behave very much the same as the 42,000 lb and 48,000 lb data for 35% deflection landings (Figure 31). However, the cross over point is shifted to the right for the 50% deflection landings. In Figure 31 the probability of experiencing an impact vertical peak load equal to or greater than 13,000 lbs was approximately 23% for both aircraft weights. In Figure 32 the cross over occurs at 17,000 lbs and 5%. This shift is due, in part, to the aircraft weight difference between the groups of data. The two plots under consideration in Figure 31 differ by a weight of 6,000 lbs while in Figure 32 the difference is 9,000 lbs. It is interesting to observe that, for 3% of the landings at both weights, there is a higher probability of equaling or exceeding a given impact vertical peak load greater than 17,000 lbs for a 42,000 lb aircraft than for a 51,000 lb aircraft. Again, the reason appears to be pilot technique. None of the 50% deflection landings generated impact vertical peak loads in excess of 0.6 vertical design load.

(3) 35% Versus 50% Tire Deflection (Figure 33): Unfortunately, the only aircraft weight condition at which both 35% and 50% deflection landings were made in sufficient numbers for comparison was 42,000 lbs. Thus, Figure 33 compares the impact vertical peak loads experienced during landings at 35% and 50% deflection at 42,000 lbs gross weight. These plots do not agree with the "expected trend" since the exceedance probability for any given impact vertical peak load is consistently greater for a landing at 50% deflection than it is for one at 35% deflection. The reason for this is presently unknown.

b. Overall Vertical Peak Loads

(1) 35% Tire Deflection (Figure 34): The data agree with the "expected trend". The slope of the upper part of the curve for 42,000 lbs gross weight is less than it is for the other two conditions because 45% of the 42,000 lb landings were touch-and-go's. Of the 42,000 lb landings, none generated overall vertical peak loads in excess of 0.6 vertical design load, while 12% of the 48,000 lb landings and 100% of the 56,000 lb landings exceeded this value.

(2) 50% Tire Deflection (Figure 35): The data follow the "expected trend" for overall vertical peak loads greater than 11,000 lbs. Below this vertical load value the curves cross, clearly showing the influence of a bimodal distribution of loads. This occurs because touch-and-go landings comprise 45% of the landings at 51,000 lbs gross weight, and only 20% of the landings at 42,000 lbs gross weight. None of the 42,000 lb landings generated overall vertical peak loads in excess of 0.6 vertical design load while 40% of the 51,000 lb landings exceeded this value.

Drag Peak Loads

Description of Figures: Figures 37 through 41 show the frequency of occurrence of drag peak load for various combinations of gross weight and tire deflection. They depict the probability of equaling or exceeding a given drag peak load for a specific landing condition based on experience gained during this test program. A line is drawn at 0.3 drag design load for reference. The choice of 0.3 drag design load as a reference was arbitrary. Table XXIX contains the data from which the frequencies of occurrence plotted in Figures 37 through 41 were computed.

*Expected Trends*

a. *Impact Drag Peak Loads:*

*(1) The impact drag peak load versus frequency of occurrence curves (Figures 37 and 38) should be ranked by gross weight so that the curve for 56,000 lbs would lie above the curve for 51,000 lbs which would lie above the curve for 48,000 lbs, etc.*

*(2) The impact drag peak loads at 50% tire deflection should be greater than those at 35% tire deflection for a given gross weight (Figure 39). At 50% deflection the tires are softer, have a higher rolling resistance, and a greater foot print area than they do at 35% deflection. This could cause higher spin-up torque on impact as well as increased drag during rollout.*

b. *Overall Drag Peak Loads:*

*(1) The overall drag peak load versus frequency of occurrence curves (Figures 40 and 41) should be ranked by gross weight just as with the impact drag peak load curves.*

Modifying Factors

a. Effects of Touch-and-go Landings On Overall Drag Peak Load Curves: For a given gross weight and tire deflection, the ratio of the number of touch-and-go landings to full-stop landings significantly affected the shape of the overall drag peak load curves (Figures 40 and 41). While the full-stop landings all required some braking, no braking was used for touch-and-go landings. Thus in most cases, the impact drag peak load and the overall drag peak load were the same for touch-and-go landings and these loads were generally lower than the drag peak loads for full-stop landings. They had the effect of:

(1) Shifting the upper part of the curve to the left and downward.

(2) Flattening the "knee" of the curve.

b. Variations In Braking Procedure: The original flight test plan for this program specified that full-stop landings would be made at each gross weight using light, moderate, and heavy braking in order to measure variations in tire wear and performance. This was to be done with wheel brakes only; reverse thrust was not to be used. The first 34 test missions were flown at 42,000 lbs gross weight and 35% tire deflection. On flights 20 through 25 moderate to heavy braking was used and on the fourth landing of flight 25 a tire blew out as a result of a locked brake. Figure 42 presents a time history of this landing. The brake malfunction was caused by overheating. There was a cumulative heat buildup from heavy braking on the three previous landings, even though the landings were spaced at least 30 minutes apart to provide cooling time for both brakes and tires. Because of this problem, the procedure was changed and, for the remainder of the program, reverse thrust was used to reduce the braking loads. Braking intensity was reduced to moderate or less through flight 34. Therefore, most of the braking was of light intensity. Thus, the 42,000 lb gross weight, 35% tire deflection category has a higher percentage of large overall drag peak loads than the other categories.

c. Effects Of Reverse Thrust On Overall Drag Peak Loads: The use of reverse thrust tended to minimize variations in overall drag peak loads as gross weight increased. At higher gross weights, the pilot would wait longer to apply the brakes than at lower gross weights, letting the reverse thrust do the work of slowing the aircraft to a speed where light braking could be used to effect a complete stop. The end result was that the brakes were usually applied at about the same ground speed, regardless of the gross weight, and this speed was low enough to produce reasonably small drag loads.

d. <u>Effects Of Aircraft Pitch Attitude On Impact Drag Loads</u>: The pitch attitude of the test aircraft at touchdown had a significant effect on the magnitude of the impact drag peak loads.

(1) Vertical loads on the main landing gear were measured along the lengthwise axis of the main landing gear strut. The drag loads were measured along an axis perpendicular to this (Figure 43). If the aircraft touched down at 0° pitch attitude the measured vertical and drag loads would be equal to the true vertical and true drag loads experienced by the gear. Touchdown with a nose high pitch attitude, however, rotated the measurement axes relative to the true vertical and true horizontal axes, which reduced the magnitude of the measured loads.

(2) If the true vertical force is resolved into components along the measurement axes (side loads are ignored, in this case), the drag component is in the opposite direction to the normal drag force and thus tends to reduce the actual drag loads experienced by the gear. The larger the pitch angle the greater the magnitude of the coupled drag component. This component can be a very significant percentage of the measured drag force, even at small pitch angles on the order of 1° to 5°.

(3) The difference between the true vertical force and the measured vertical force is very small for small pitch angles and is, therefore, neglected. Furthermore, the component of the true drag force which couples with the vertical axis is additive and, since it is also very small, tends to cancel the difference. The difference between the true and measured drag force is also negligible for small pitch angles.

(4) Aircraft pitch attitude at touchdown is largely a function of flap setting. Landings at 42,000 lbs gross weight were made with full flaps. This enabled the aircraft to maintain an almost level pitch attitude through the flare. As aircraft gross weight increased, landing flap settings were reduced, resulting in a higher nose-up pitch attitude at touchdown. Landings at 56,000 lbs gross weight were made with no flaps.

(5) Each increase in gross weight was accompanied by a decrease in landing flap setting, an increase in average aircraft pitch attitude at touchdown and, therefore, an increase in the magnitude of the coupled (subtractive) drag component. The end result was that as gross weight was increased, the impact drag loads did not increase in proportion thereto.

Discussion Of Curves

a. Impact Drag Peak Loads

(1) 35% Tire Deflection (Figure 37): The data points for landings at all three weights fall very close to each other over the entire range of drag peak loads. Contrary to "expectations", the probability of obtaining a given impact drag peak load is greater for a 42,000 lb aircraft than for a 48,000 lb aircraft. This is essentially the same situation described previously for impact vertical peak loads (Figure 31). There is, of course, a definite correlation between the magnitude of the impact vertical loads and the impact drag loads, but this correlation is modified by the effect of variations in aircraft pitch attitude at touchdown with increasing gross weight. Consequently, the large separation between the data for 56,000 lb landings and that for the other weights, which is seen in Figure 31, is not present in Figure 37. Less than 2% of the landings at each weight generated impact drag peak loads in excess of 0.3 drag design load.

(2) <u>50% Tire Deflection (Figure 38)</u>: The data again disagree with the "expected trend" and for the same reason discussed in the preceding paragraph. However, the separation between the curves is much larger for 50% deflection than it was for 35% deflection (Figure 37). Of the 42,000 lb landings, 5.7% generated impact drag peak loads greater than 0.3 drag design load, while less than 1% of the 51,000 lb landings exceeded this value.

(3) <u>35% Versus 50% Tire Deflection (Figure 39)</u>: The data conform to "expectations" in that there is a higher probability of equaling or exceeding a given impact drag peak load at 50% deflection than at 35% deflection. The difference between the two curves is not great, however; a maximum of 6% in terms of probability (frequency of occurrence). Only 5.7% of the 50% deflection landings, versus 1.8% of the 35% deflection landings, generated impact drag peak loads greater than 0.3 drag design load.

b. <u>Overall Drag Peak Loads</u>

(1) <u>35% Tire Deflection (Figure 40)</u>: As in the case of the impact drag peak load plots (Figure 37), the data points for all three gross weights lie close together. The 42,000 lb data has been shifted to the right because of the braking techniques used for the 42,000 lb landings. The separation between the 48,000 lb and the 56,000 lb curves has been minimized by the use of reverse thrust and light braking. Less than 3% of the 35% deflection landings generated overall drag peak loads in excess of 0.3 drag design load.

(2) <u>50% Tire Deflection (Figure 41)</u>: Again, the data reversed the "expected trend" and the probability of obtaining a given overall drag peak load is greater for a 42,000 lb landing than for a 51,000 lb landing. In this case, the 51,000 lb data is shifted to the left by a high percentage of touch-and-go landings. Only 20% of the 42,000 lb landings were touch-and-go's while 45% of the 51,000 lb

landings were. Less than 6% of the 50% deflection landings generated overall drag peak loads in excess of 0.3 drag design load.

## CONCLUDING REMARKS ON MAIN LANDING GEAR LOADS

The main landing gear loads experienced during this flight test program presented no large surprises. In most cases the loads either agreed with engineering theory and experience, or they disagreed for reasons which could be analyzed and understood. One exception to this is seen in Figure 33 where the frequency of occurrence of a given impact vertical peak load is greater for 50% tire deflection than for 35% tire deflection. This is contrary to what was expected and the reason for the contradiction is unknown.

One result of considerable interest is the fact that impact drag peak loads do not increase in proportion to increases in aircraft gross weight (Figure 37). Indeed, under some circumstances, they tend to decrease (Figure 38).

The C-131B has a very sturdy main landing gear and operation with folding sidewall tires did not result in excessive stresses on the gear.

a. The largest recorded impact vertical peak load occurred on a 42,000 lb landing at 35% tire deflection and was less than 60% of vertical design load. The largest recorded overall vertical peak load occurred on a 56,000 lb landing at 35% tire deflection and was 82% of vertical design load.

b. The greatest recorded impact and overall drag peak loads, both of which occurred on a 42,000 lb landing at 50% tire deflection, were equal and were only 34% of design drag load.

## CONCLUSIONS

The following comments pertain to the folding sidewall test tires:

a. The test tires exhibited excellent tread wear qualities. Based on the tread depth remaining on the 17 tires evaluated, a projected average tread life of 243 landings per tire was computed.

b. The stretched tread offered adequate cut and tear resistance. When cuts did occur, cut propagation was negligible.

c. The tires were operated at 50% tire deflection without serious reduction of carcass life. Approximately 25% of the test landings were made with 50% tire deflection.

d. Operation at 50% tire deflection did result in increased tread wear rate and decreased tire folding quality.

e. Tire folding quality was degraded by long periods of inactivity when the aircraft was parked on the ramp. Some restoration of folding qualities could be obtained by accomplishing several inflation/deflation cycles.

f. The tires demonstrated satisfactory runflat capability. On both runflat evaluations, the tires folded properly and remained on the wheels. No aircraft damage resulted and no debris was found on the runway. Aircraft directional control was good and ground handling characteristics were generally satisfactory.

g. The bead spacer mechanism installed in the test tires performed satisfactorily and kept the bead seated firmly against the wheel rim during runflat operation.

The performance of the rapid-response inflation/deflation system was adequate. The test tires could be inflated to a specified pressure within 10 seconds. Deflation and folding could be accomplished within 15 seconds.

Operation of the test aircraft with the test tires installed created no significant problems in ground handling or control, and did not impose excessive loads on the main landing gear, even during runflat operation.

## RECOMMENDATIONS

The following comments pertain to the folding sidewall test tires:

a. A repetitive problem encountered during the test was splitting of the rubber on the sidewalls in the area of the sidewall fold, and resultant exposure of the sidewall cord. Such splits became, with extended use of the tire, points of significant air leakage. Additional rubber stock should be applied to the sidewall area during fabrication of the tire to reduce or eliminate the splitting problem.

b. Air retention of the tires should be further improved by:

(1) Increasing the length of the down plys and the finishing strips to provide better sealing in the bead region.

(2) Rounding of the sharp edges of the bead retainer "bull" ring (part of the tire mold equipment) to reduce leakage at the corners of the bead toe flat spots.

(3) Elimination of the bead toe pin sockets, which are no longer required for the type of bead spacer mechanism used in the test program.

c. Methods of improving tire folding quality should also be investigated. Improvement of tire air retention will contribute to folding quality improvement to some extent.

An improvement in the design of the deflation system should also be accomplished for future evaluation. An air ejector device should be added to draw air out of

the test tires during the deflation cycle. This would decrease the amount of time required for deflation/retraction and would also aid in improving tire folding performance.

## LIST OF REFERENCES


1 AFFDL-TR-71-53, "Type III, Low Pressure, Folding Sidewall (Expandable) Aircraft Tire Flight Demonstration Program," by Carl P. Spier, Systems Research Laboratory Inc., September 1971

2 Military specification - Tires, Pneumatic, Aircraft; Mil - T-5041E; 14 Oct 66.

3 AFFDL-TR-71-118, "Laboratory Evaluation of a Folding Sidewall Aircraft Tire," by Paul M. Wagner, AF Flight Dynamics Laboratory, January 1972.

4 AF Flight Manual No. T.O. 1C-131B-1, C-131B Aircraft.

5 AF Technical Manual No. T.O. 4T-1-3; Inspection, Maintenance Instructions Storage, and Disposition of Aircraft Tires and Inner Tubes.

6 AFFDL-TR-70-138, "Rolling Resistance and Carcass Life of Tires Operating at High Deflections," by P. Skele, AF Flight Dynamics Laboratory, January 72.

7 Flight Test Report, 4950th Test Wing (Technical) Report 4950/ENE 71-48, "Interim Report" Aircraft Expandable Tire Demonstration," by Larry A. Roberts, 4950th Test Wing (Technical), Dated 21 October 1971, 3 pages.

8 The Tire and Rim Association Inc., Yearbook 1971, Section 8, Aircraft.

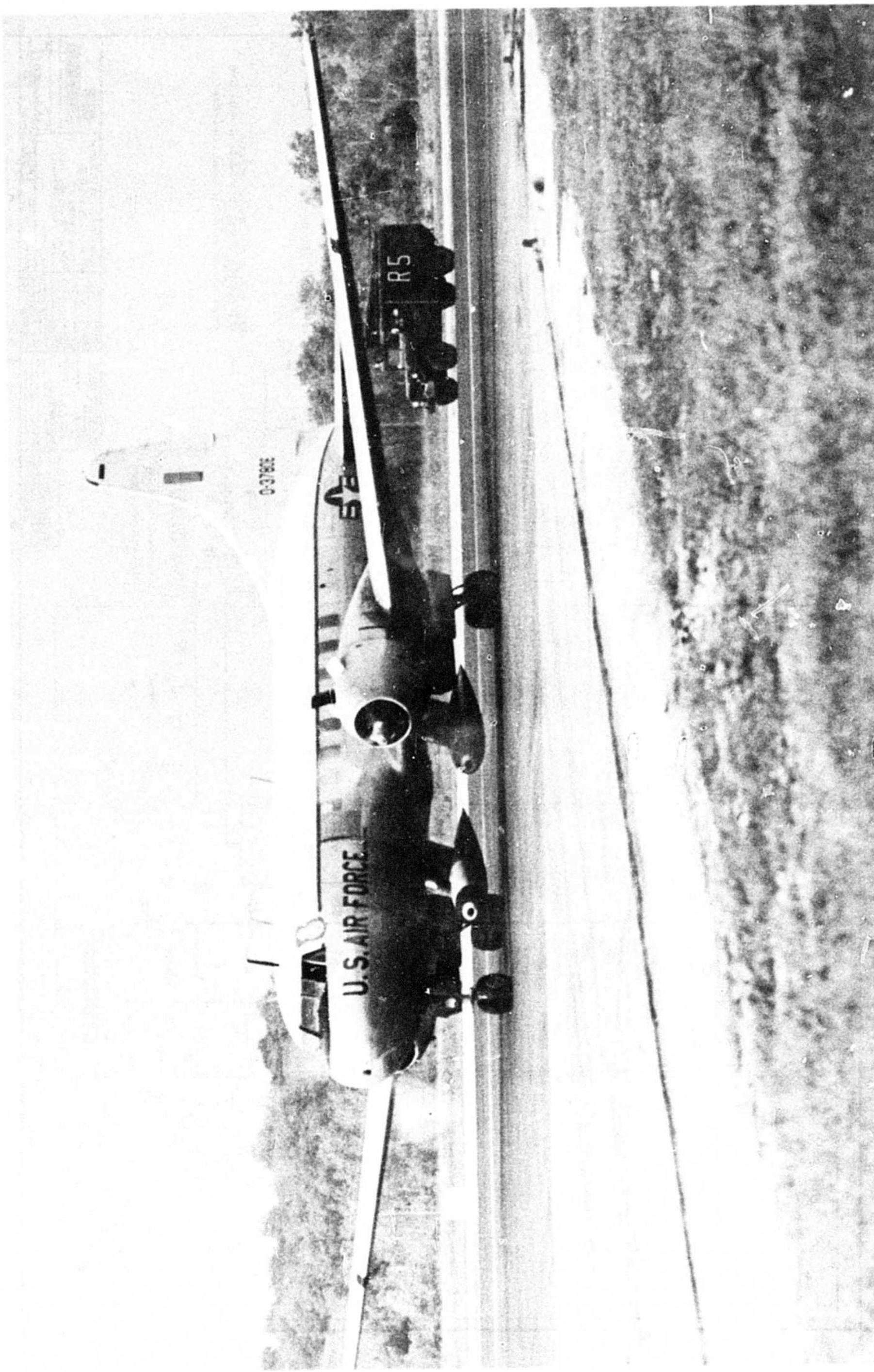


Figure 1.  The Test Aircraft JC-131B S/N 53-7806.

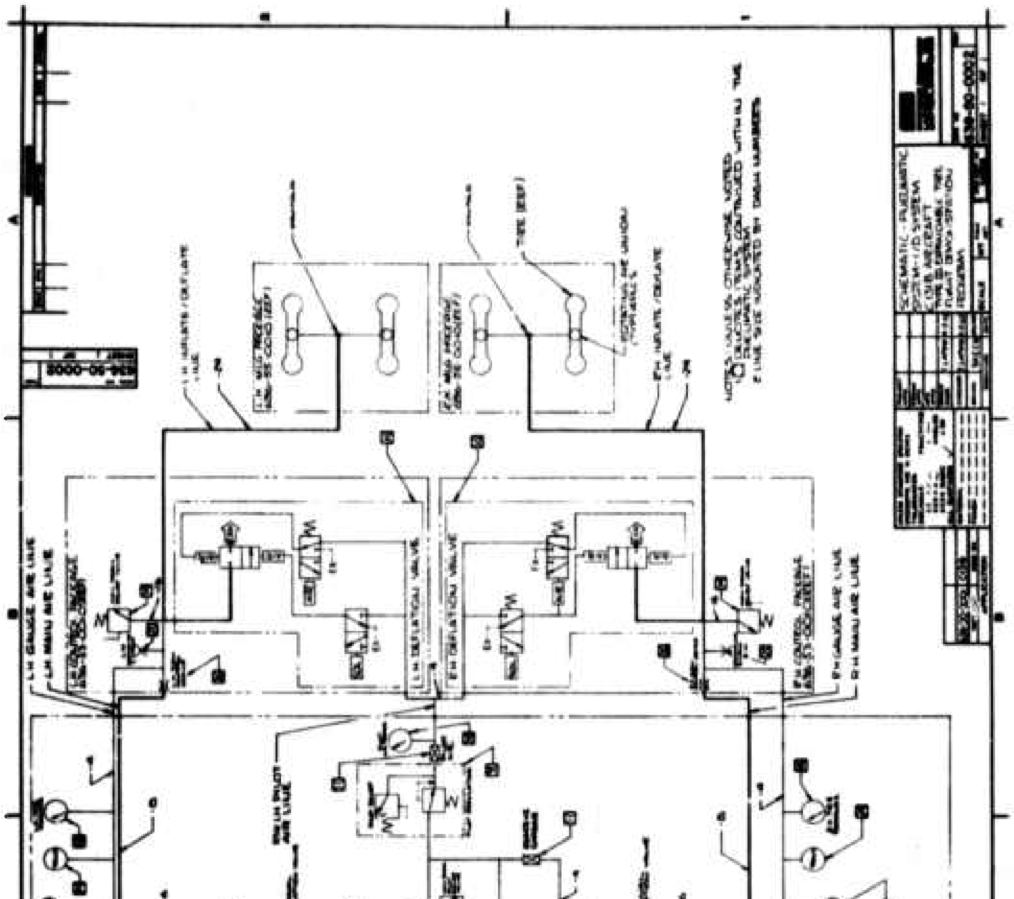

Figure 2. Schematic Diagram of the Inflation/Deflation Subsystem.

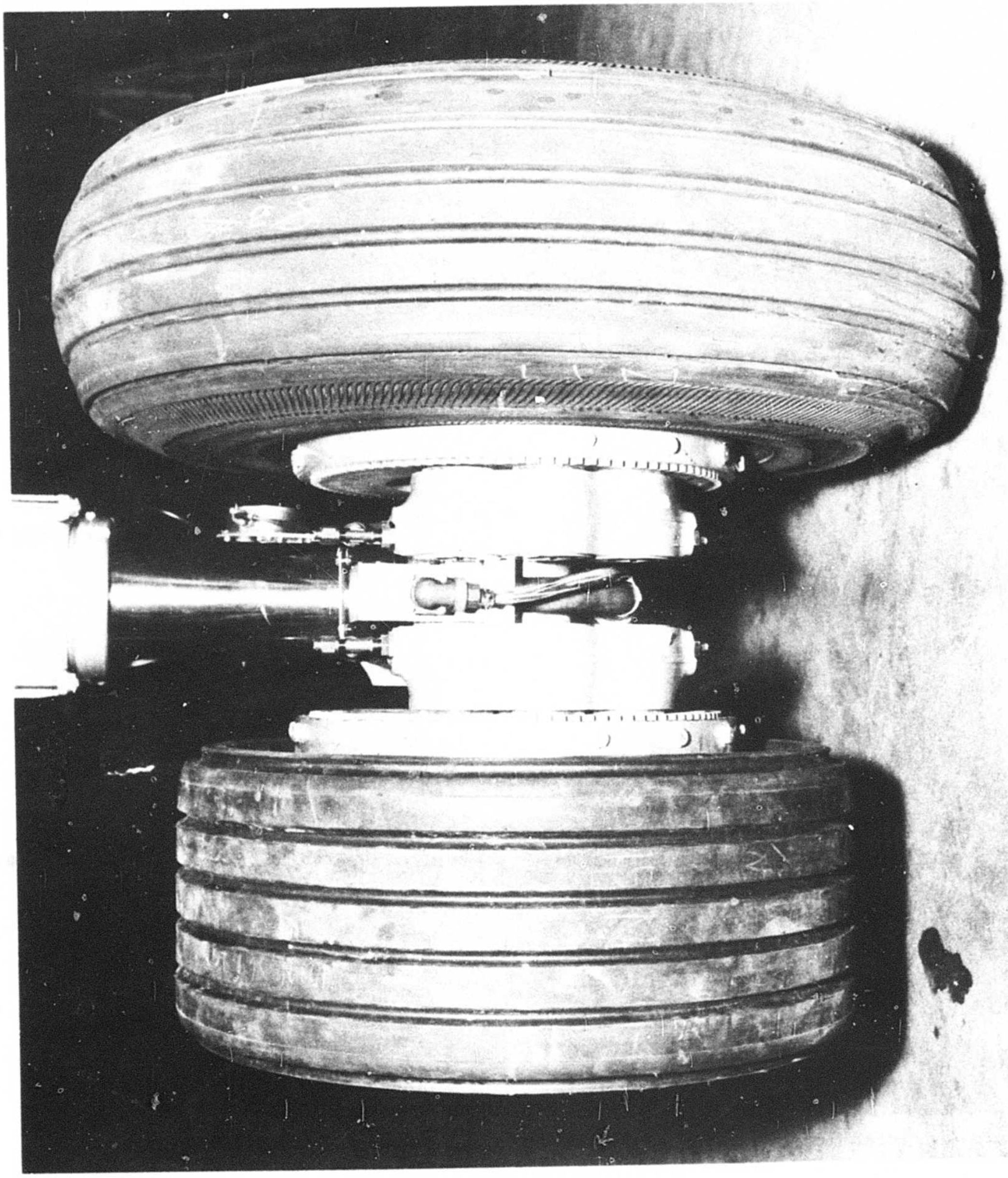

Figure 3. Folded And Inflated Flight Test Tire Comparison.

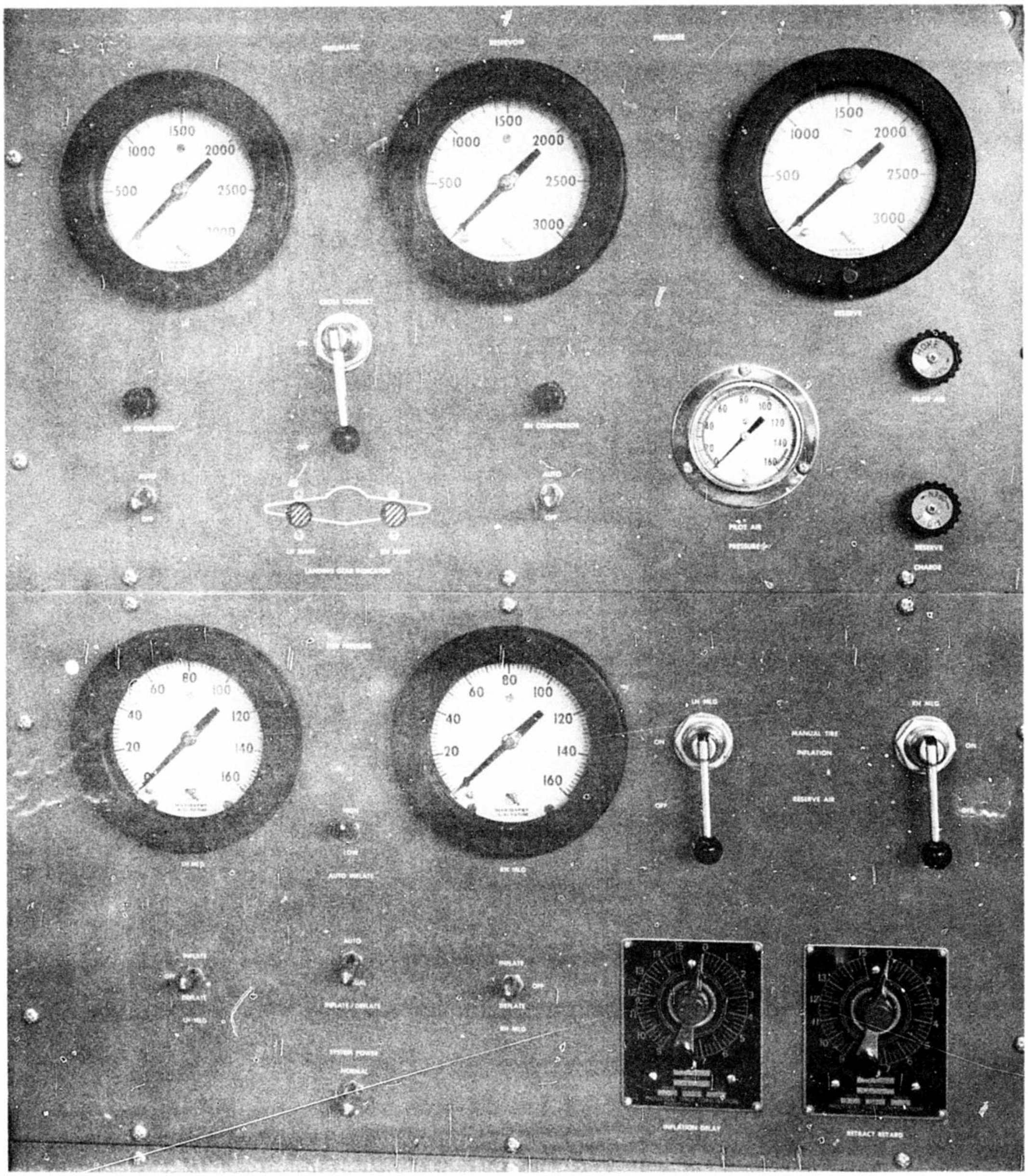


Figure 4. Inflation/deflation Subsystem Operator's Control Panel.

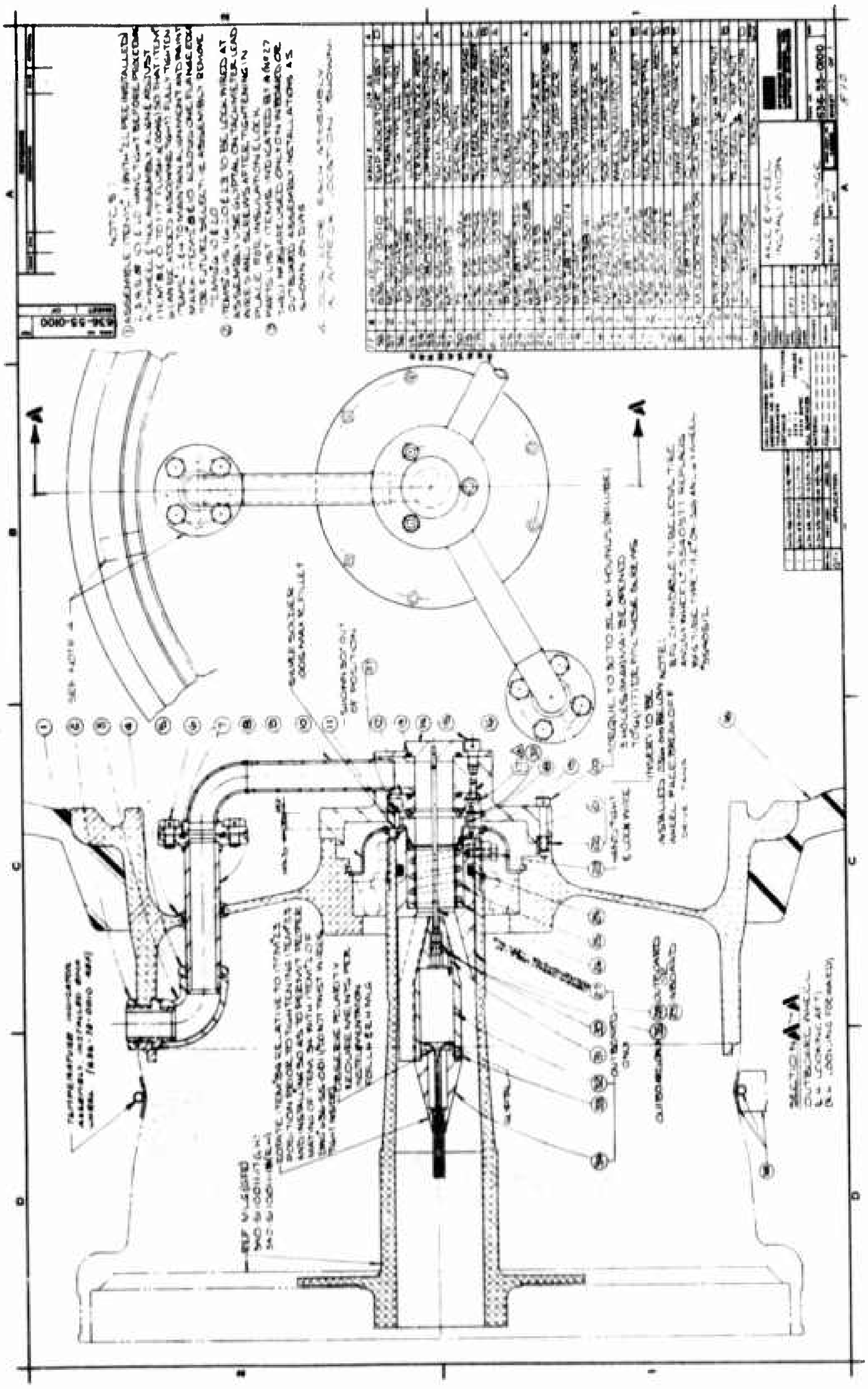

Figure 5. Axle and Wheel Assembly Details.

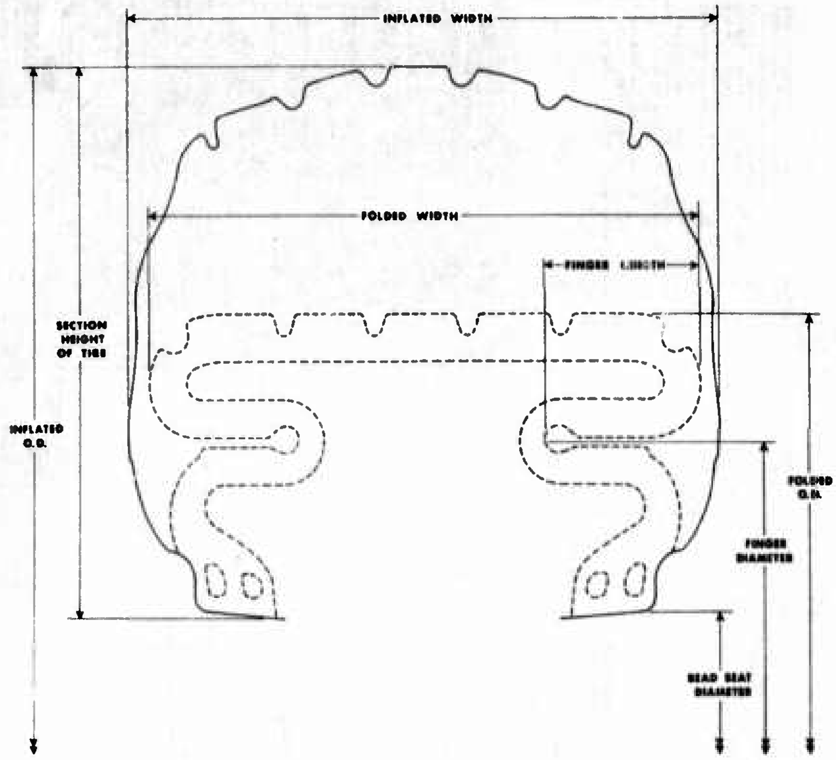


Figure 6. Folding Sidewall Tire Section Profiles.

Figure 7. Cutaway Section of Folding Sidewall Aircraft Tire Designated 38.5/28x13.0-16.

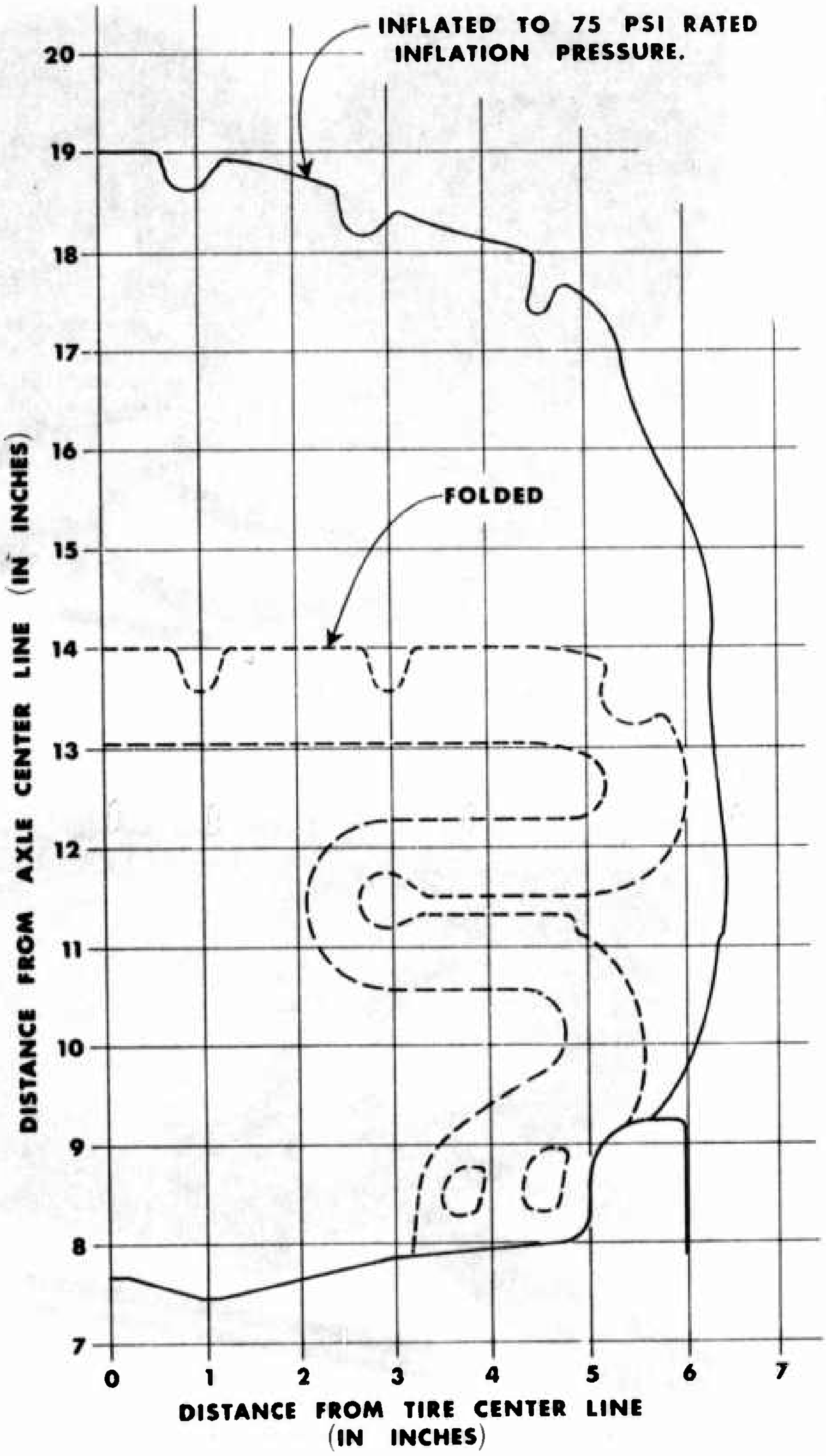


Figure 8. 38.5/28x13.0-16 Folding Sidewall Tire Cross-Sectional Shapes.

Figure 9a. Wheel and Bead Spacer Components.

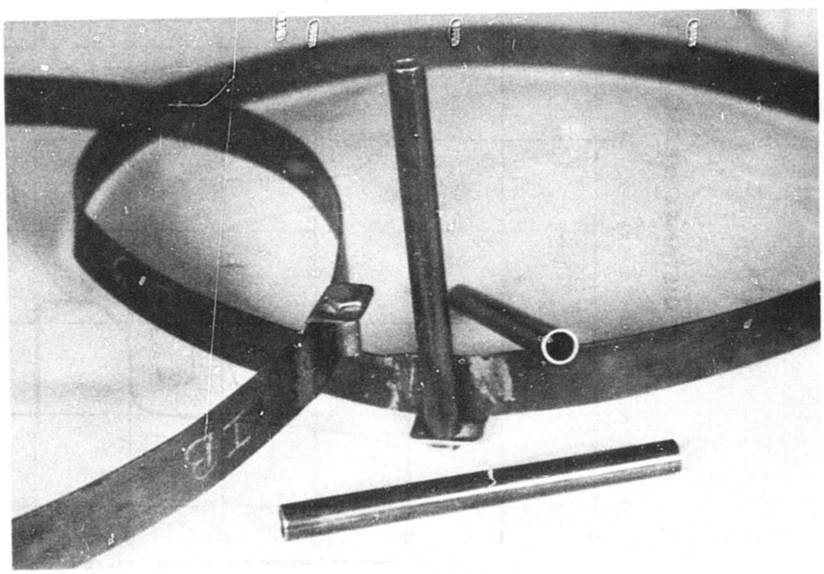

Figure 9b. Wheel Bands and Tube Spacers.

Figure 9. Bead Spacer Mechanism used in Flight Test Program (Cont'd).

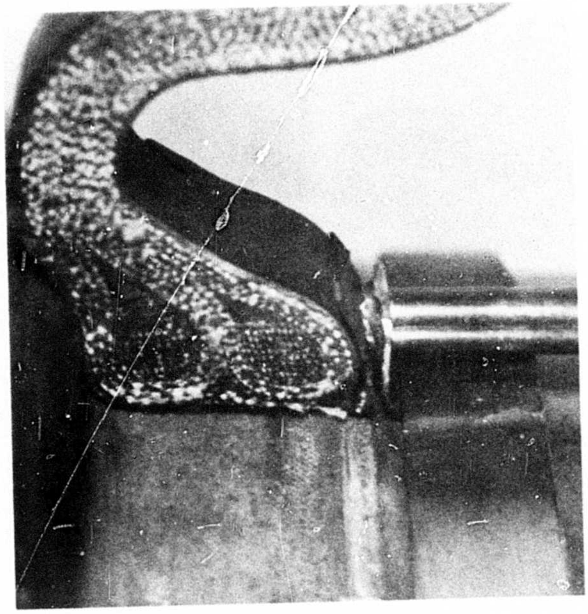

Figure 9c. Spreader Mounted Against Bead Toe.

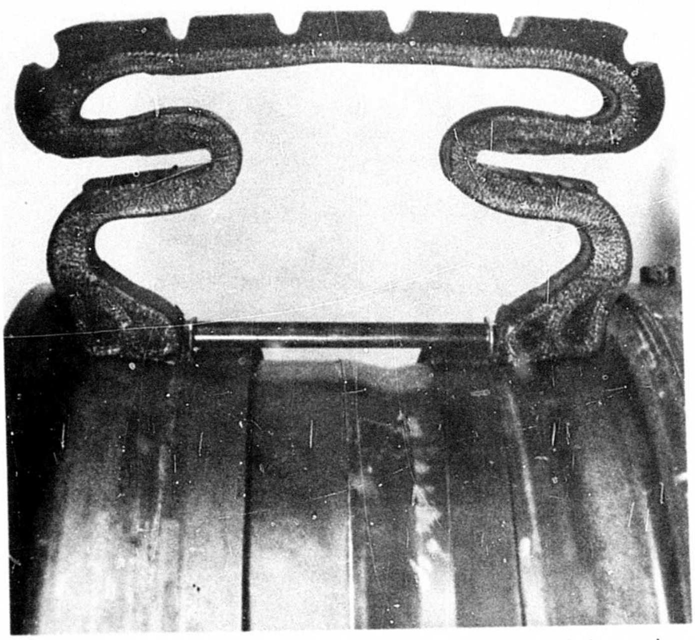

Figure 9 d. Bead Spacer Mechanism Mounted with a Tire Cutaway Section.

Figure 9 Concluded.

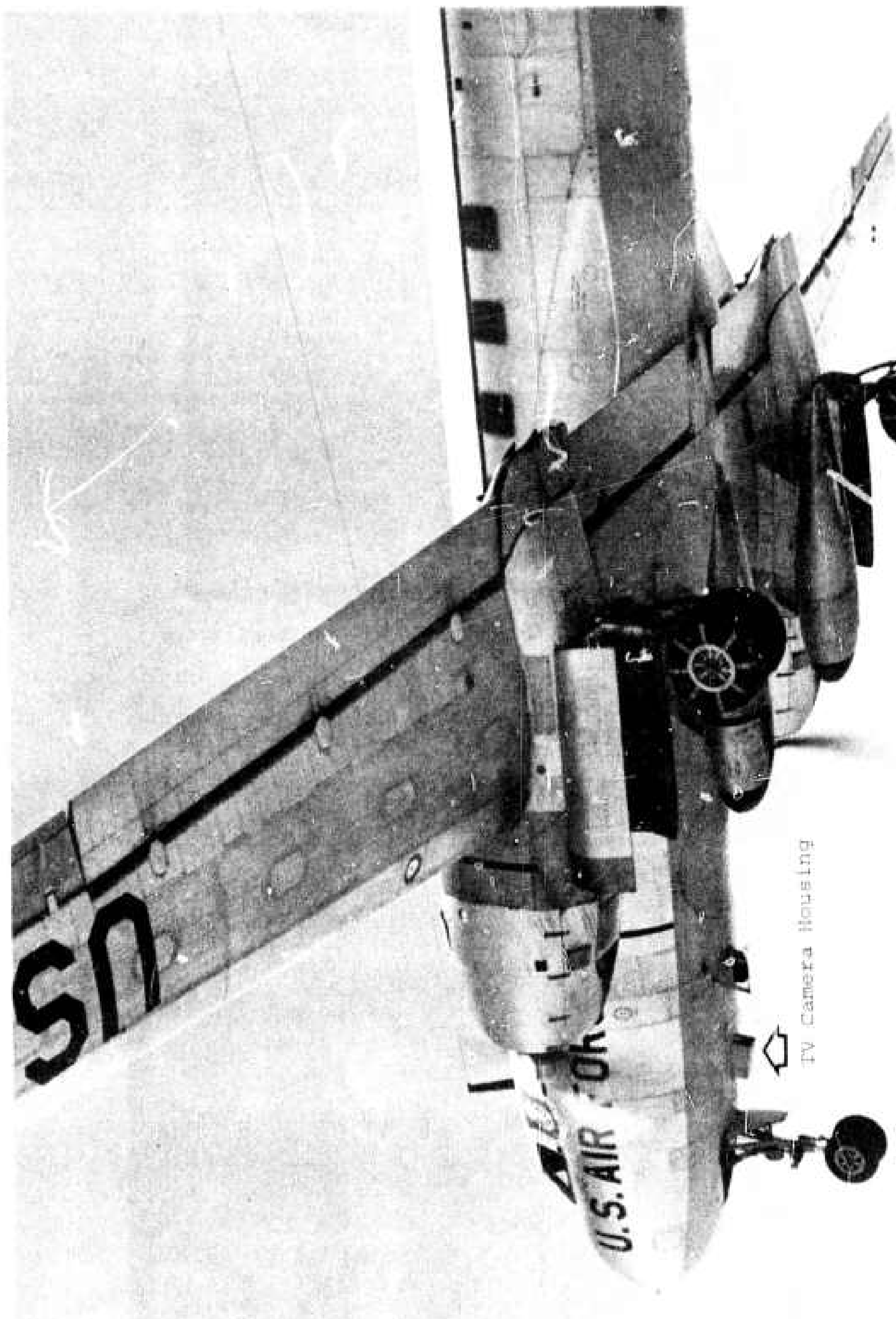


Figure 10a. Television Camera Mounted On The Belly Of The Test Aircraft (Cont'd).

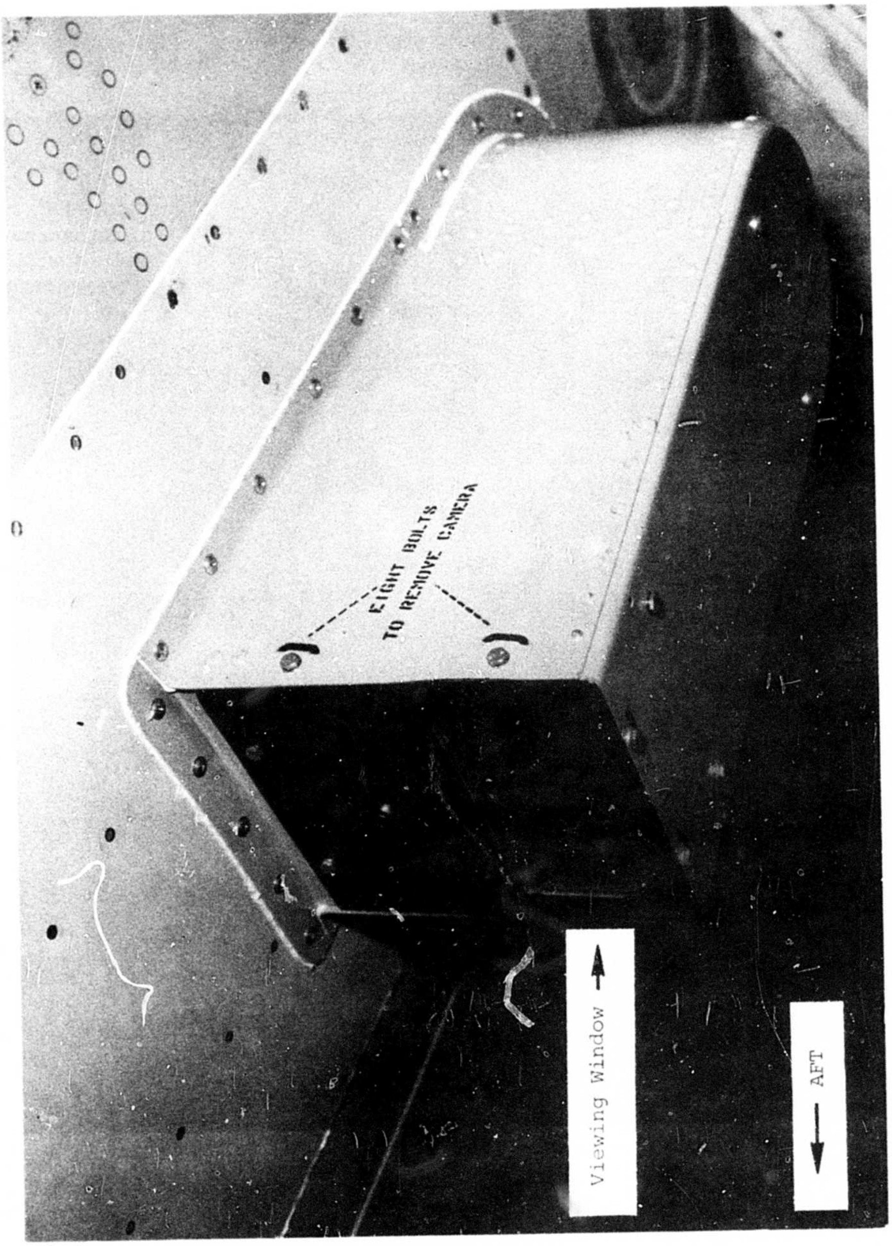


Figure 10b. Television Camera Housing.

Figure 10. Concluded.

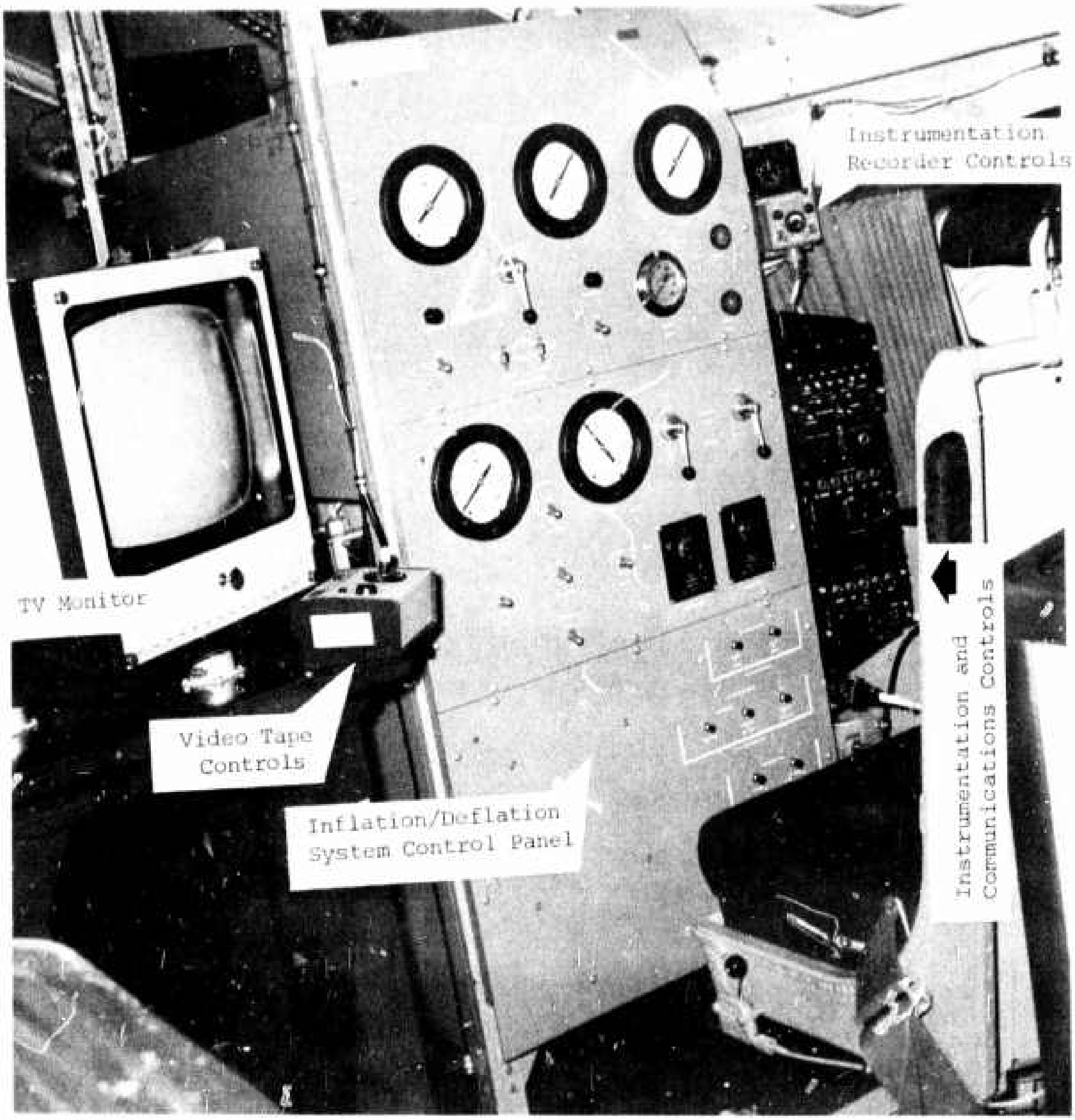


Figure 11. Test System Operator's Station.

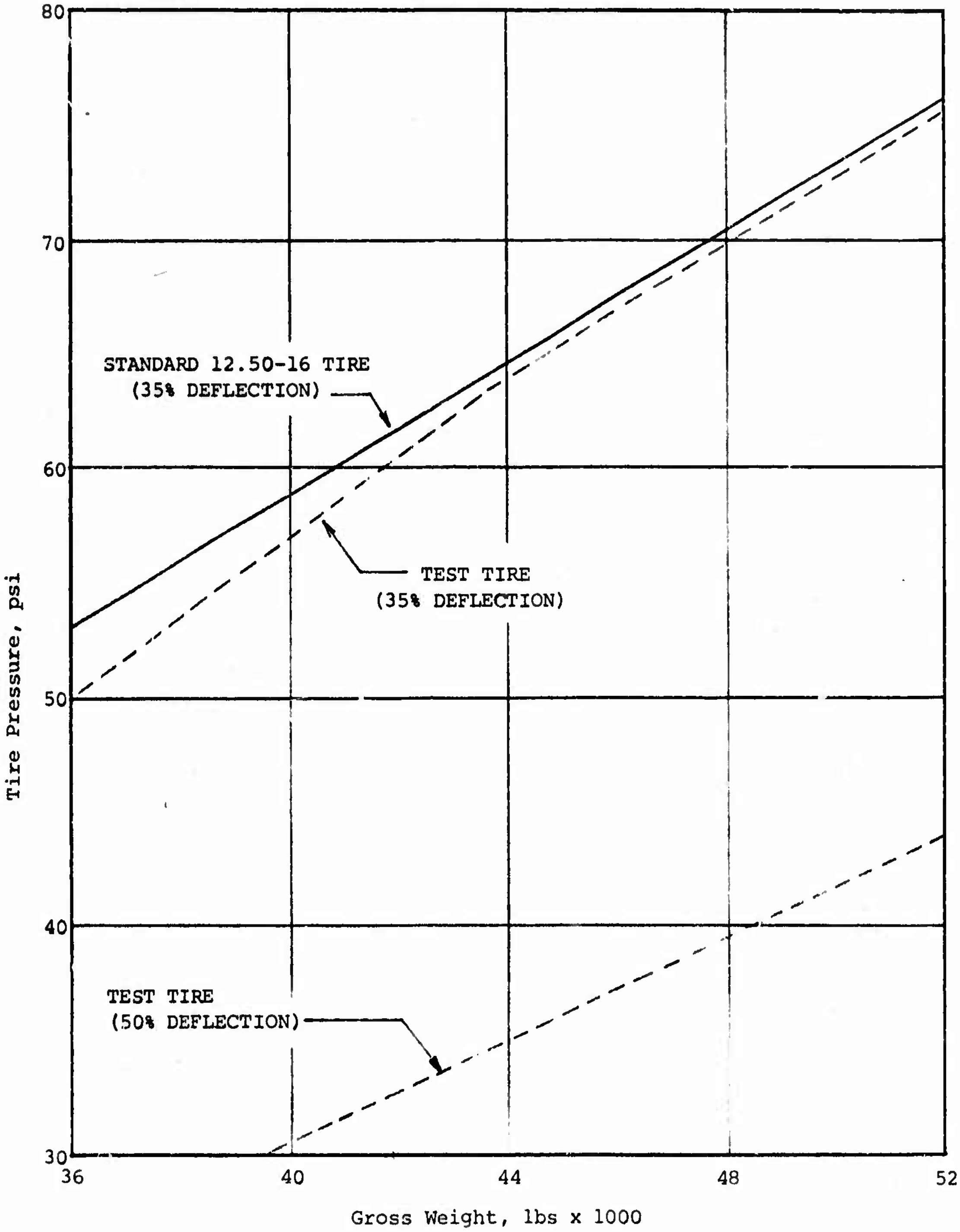


Figure 12. Tire Inflation Pressure and Aircraft Gross Weight Curves For 35% and 50% Tire Deflections.

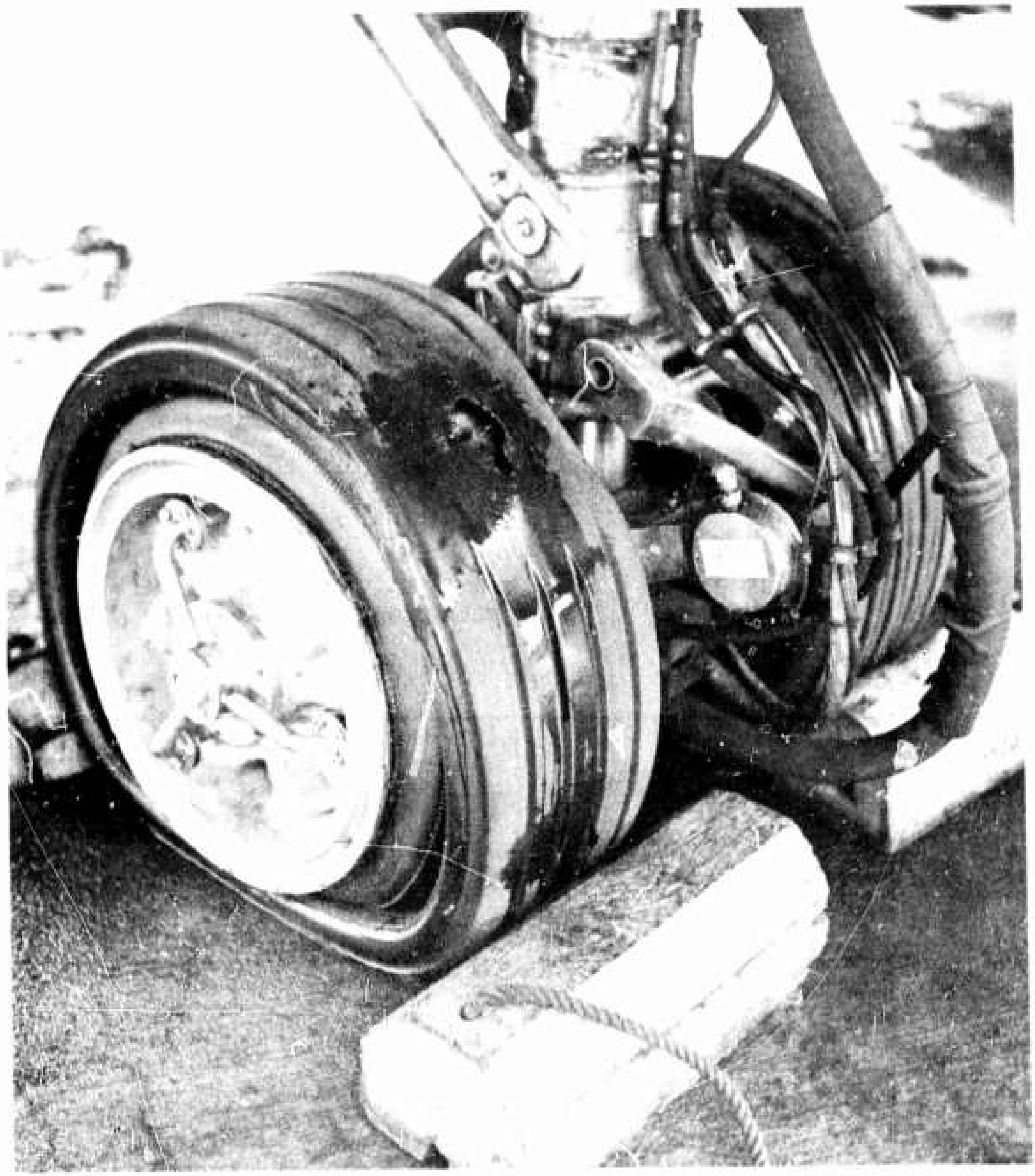

Figure 13. Tire After Blow-out And Run-flat Stop.

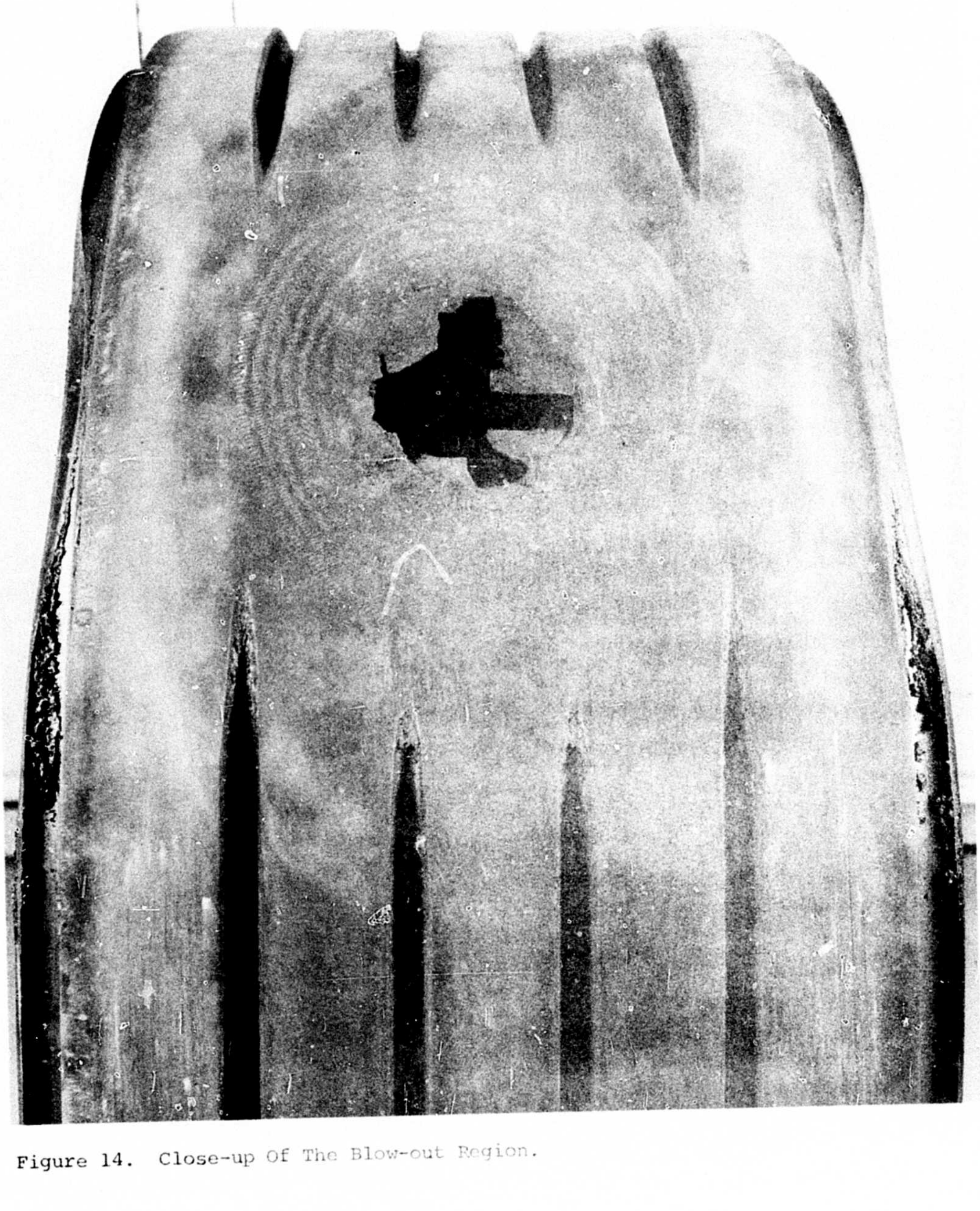

Figure 14. Close-up Of The Blow-out Region.

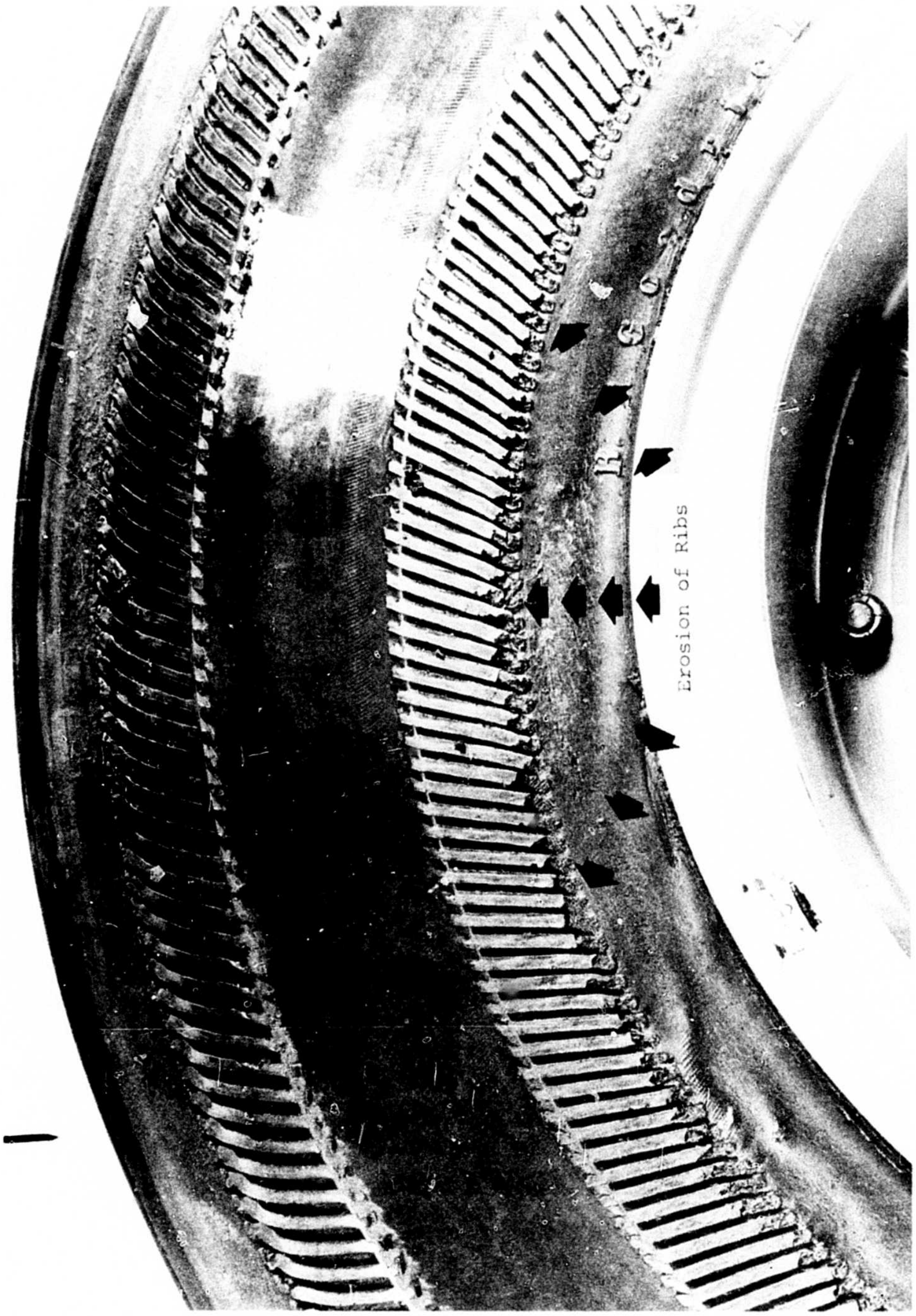


Figure 15. Tire No N51-0035-14 After Low Speed, Run-flat Rollout.

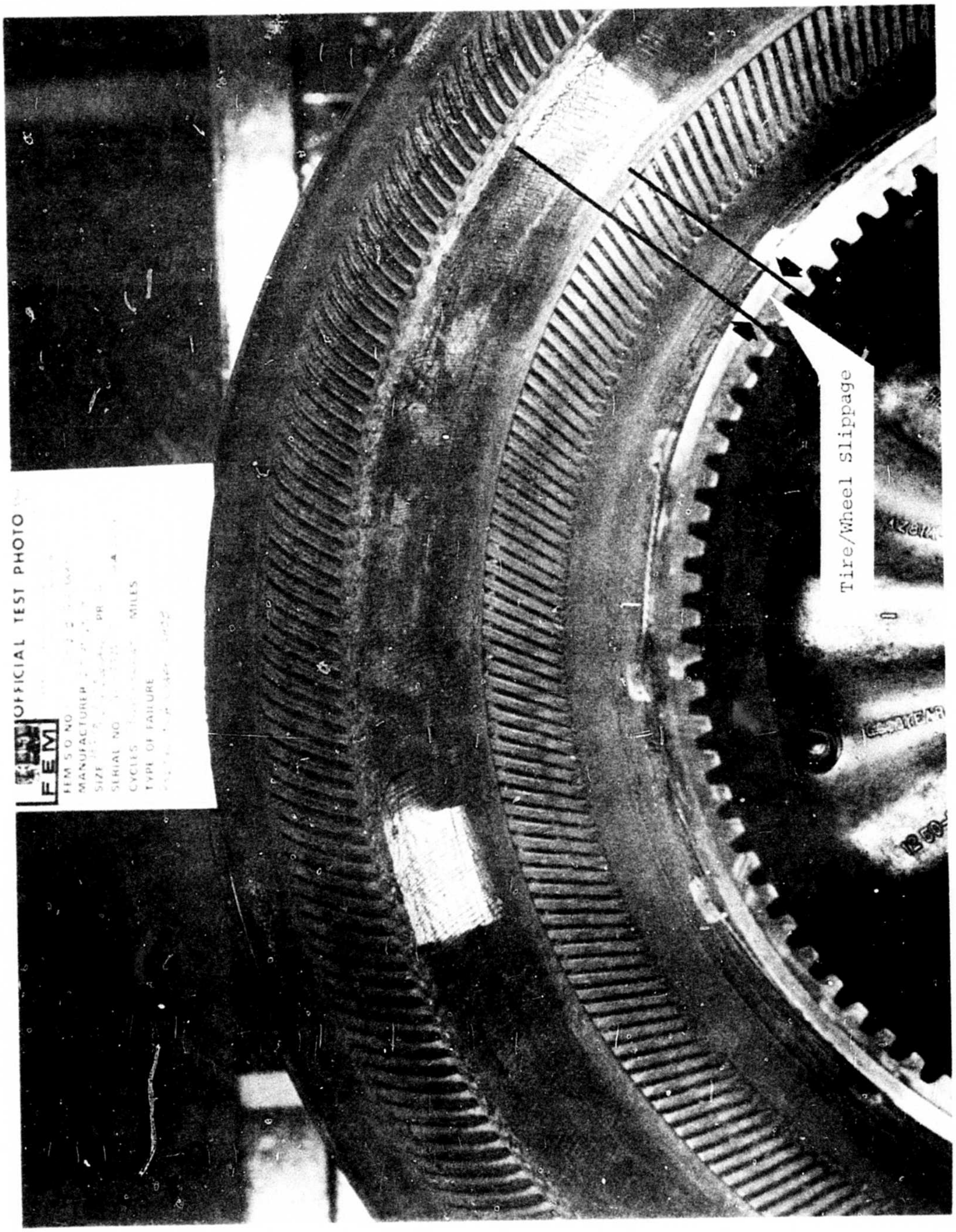


Figure 16. Close-up Of Inboard Sidewall Of Tire No N51-0035-17 After a High Speed Run-flat Rollout. Tire Is Inflated.

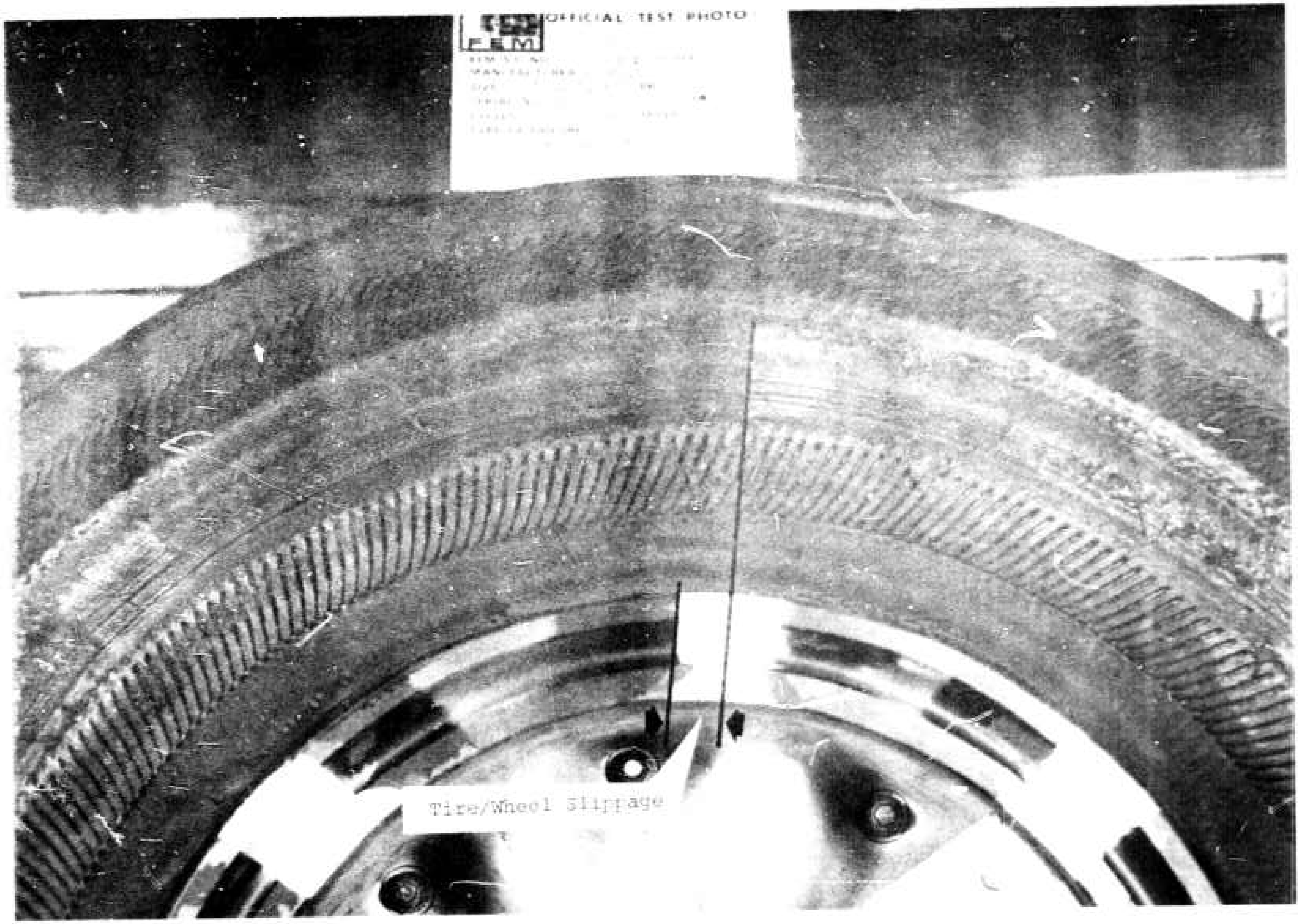


Figure 17. Close-up Of Outboard Sidewall Of Tire No N51-0035-17 After a High Speed Run-flat Rollout. Tire Is Inflated.

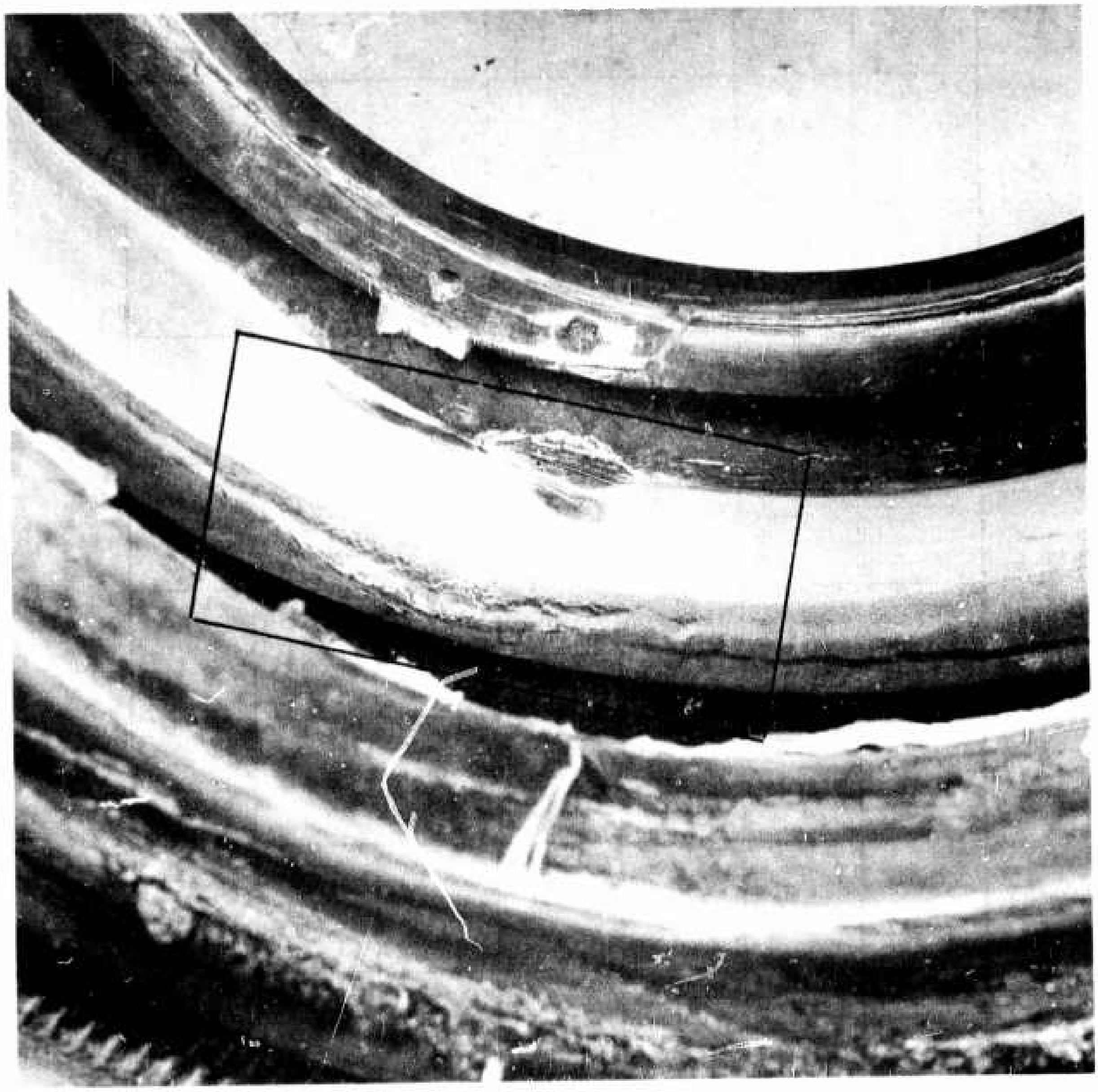

Figure 18. Chafed Area On Inner Liner Of Tire No N51-0035-11.

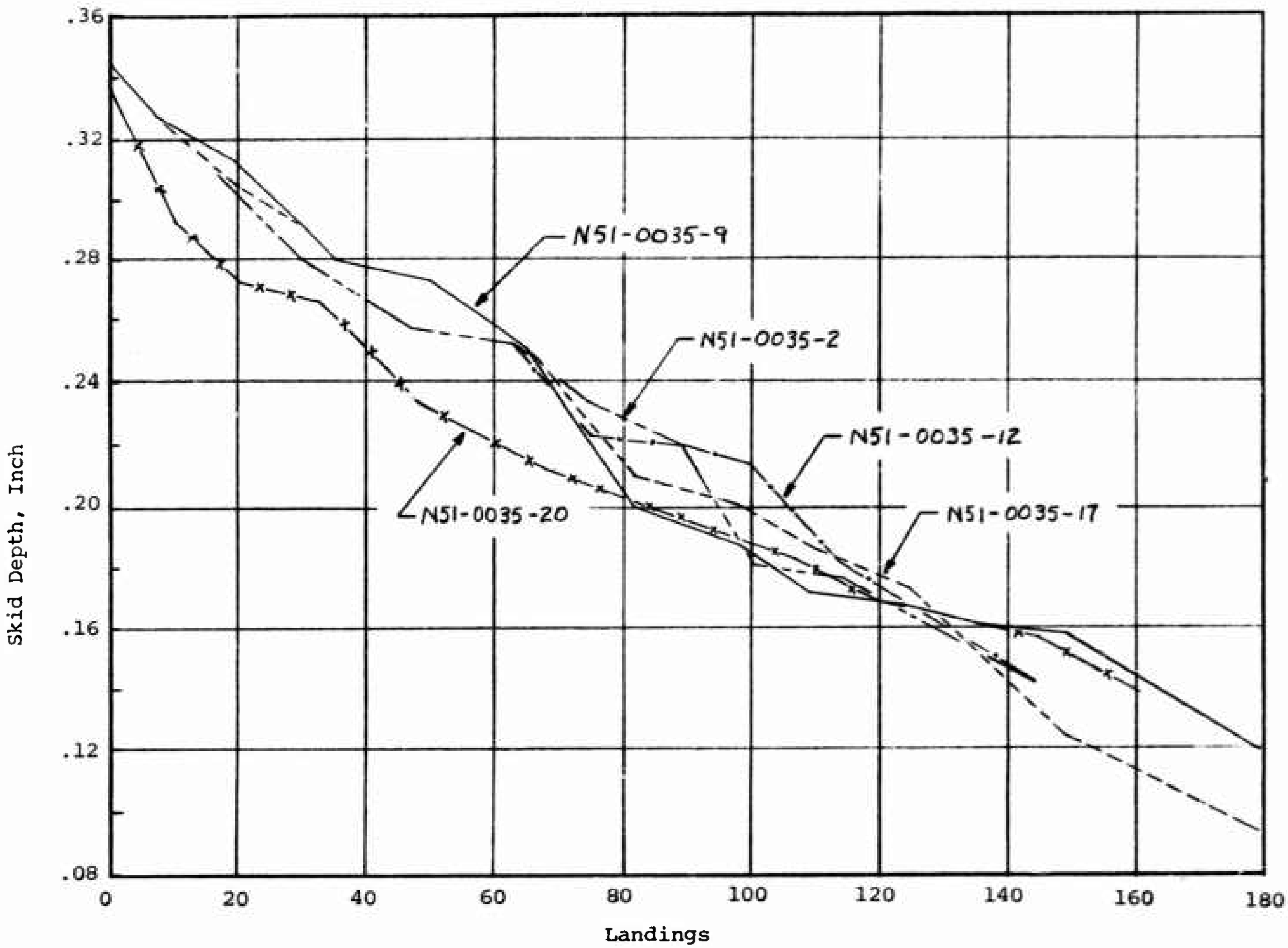


Figure 19. Tread Wear - 38.5/28x13.0-16 Folding Sidewall Aircraft Tires.

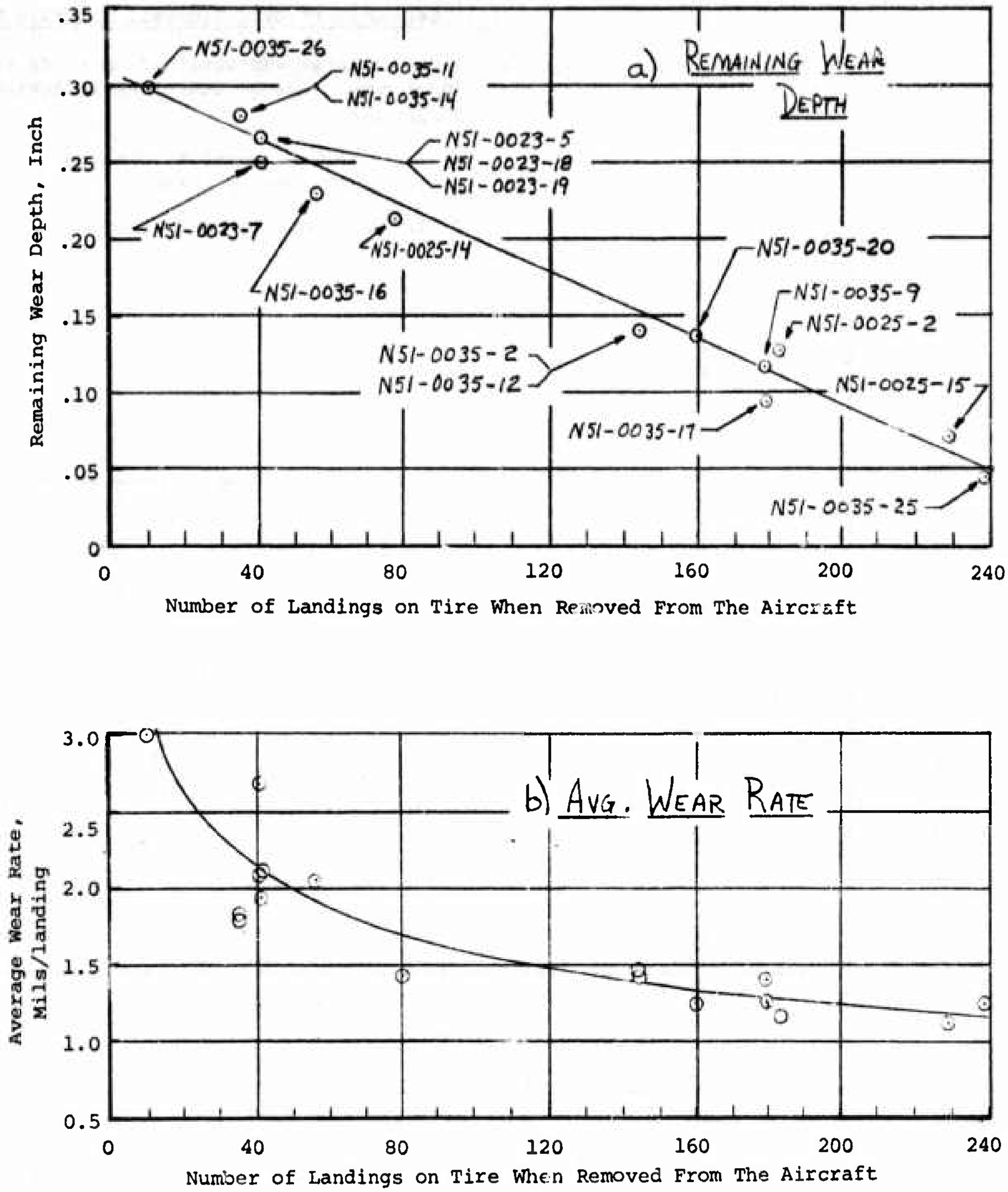


Figure 20. Tread Wear Trends-38.5/28x13.0-16 Folding Sidewall Aircraft Tires.

38.5/28x13.0-16 Folding Sidewall Aircraft Tires

1. Data presented was obtained on tires with 50 or more landings under the following conditions:

    (1) Light to moderate braking,
    (2) with reverse thrust.

2. C-131B Main Landing Gear Tire.

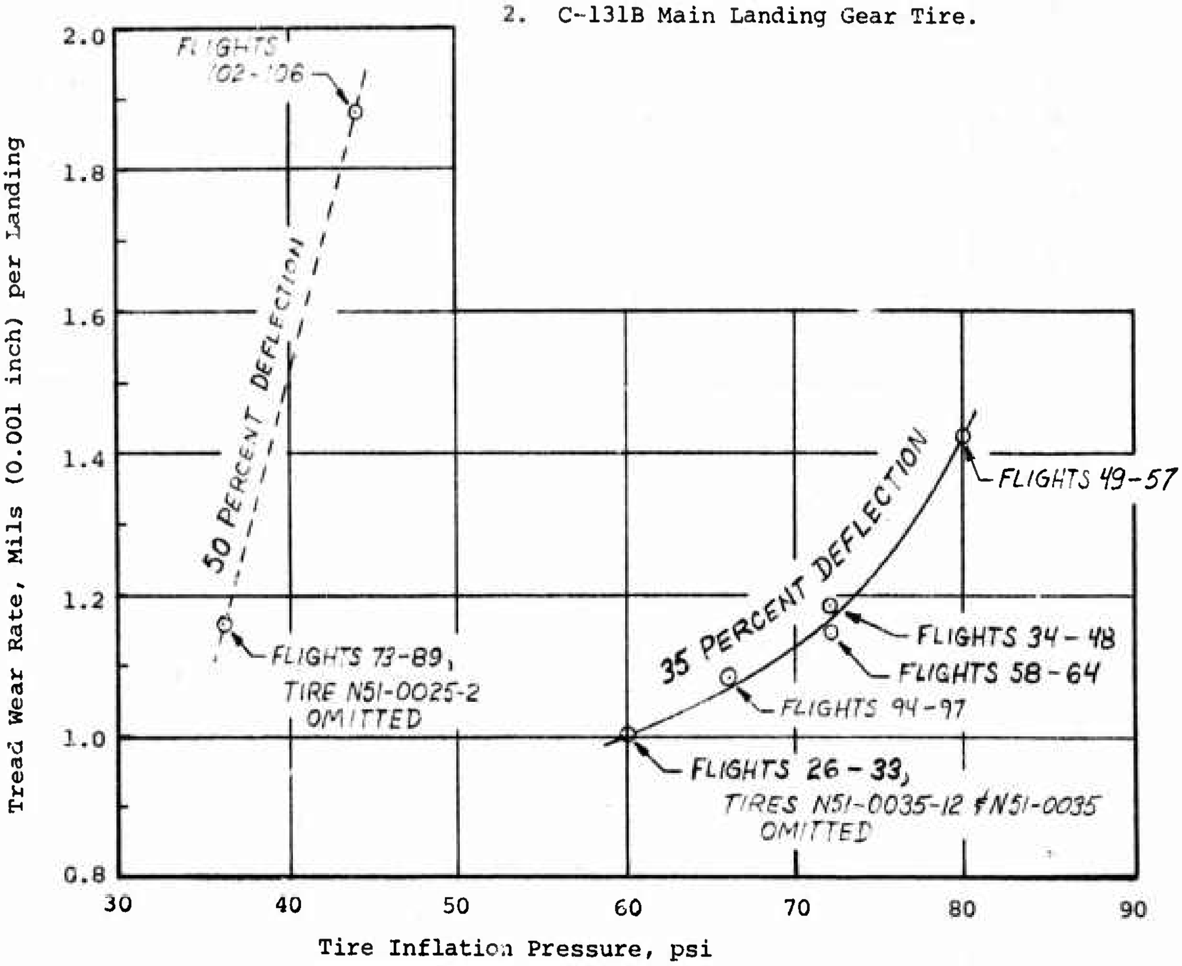


Figure 21. Variation of Tread Wear Rate with Tire Inflation Pressure for Brake-Stop Landings.

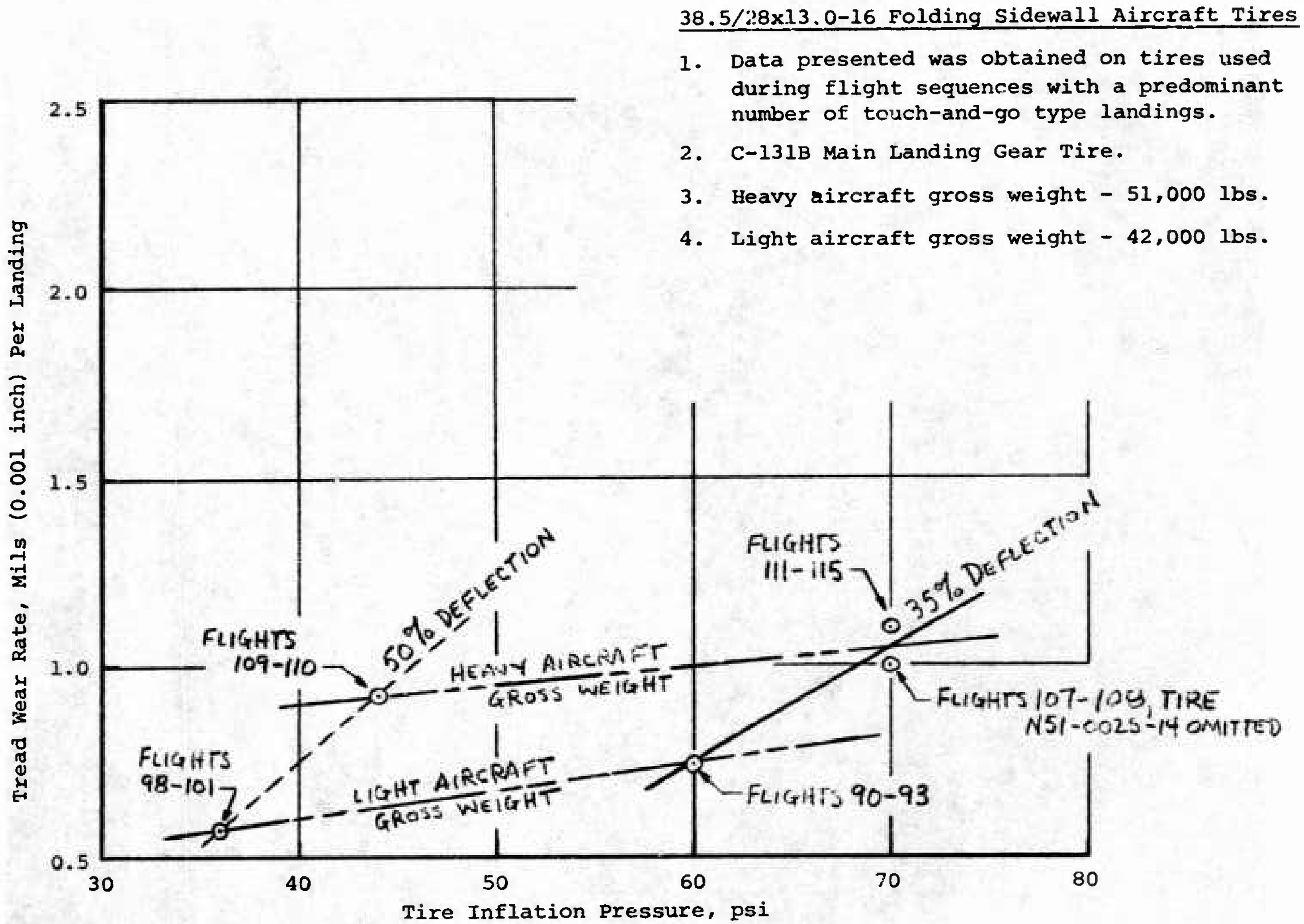


Figure 22. Variation of Tread Wear Rate with Tire Inflation Pressure for Touch-and-Go Landings.

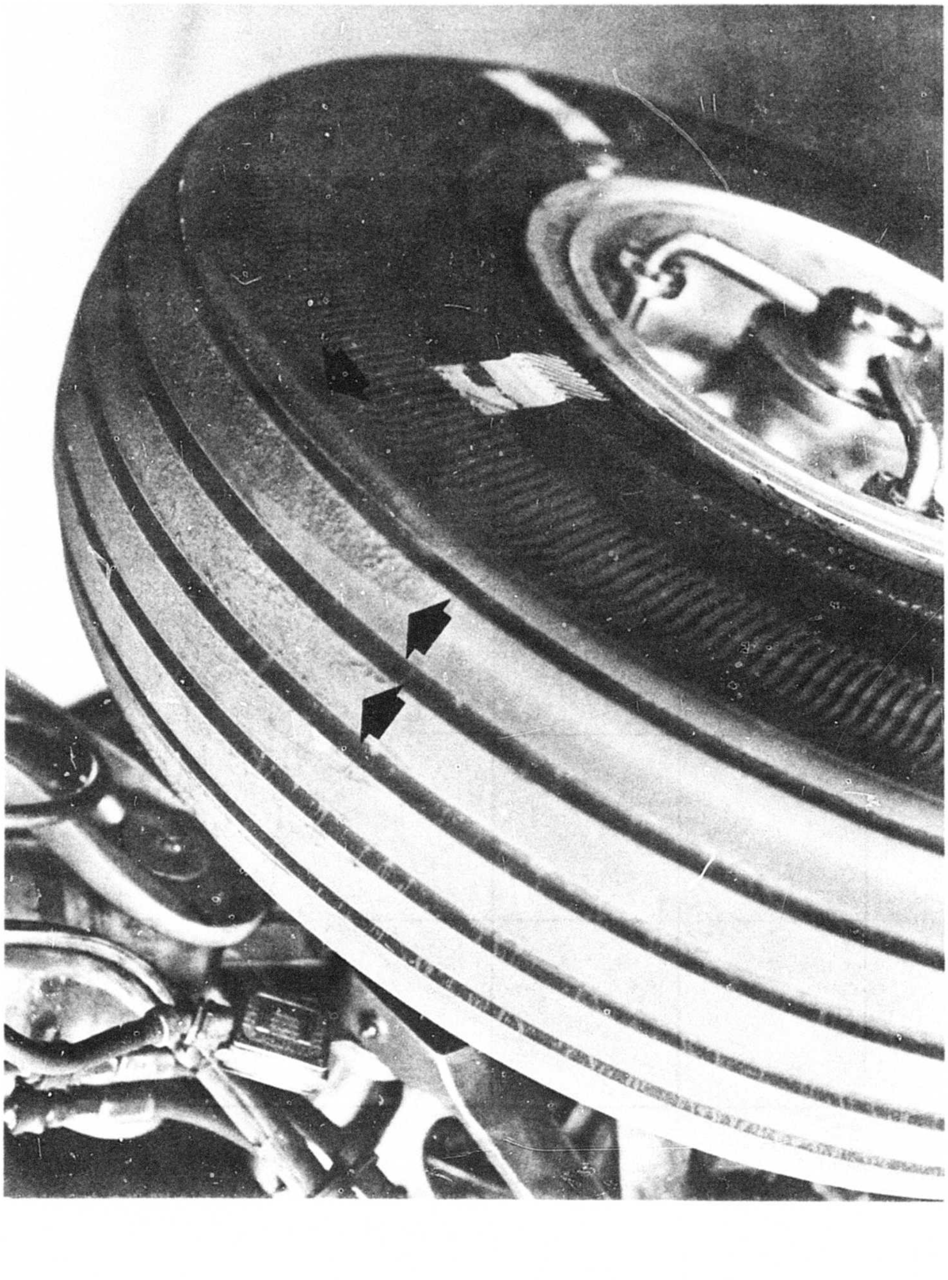

Figure 23. Reverted Rubber Skid Contact Patch On Tire No N51-0035-14.

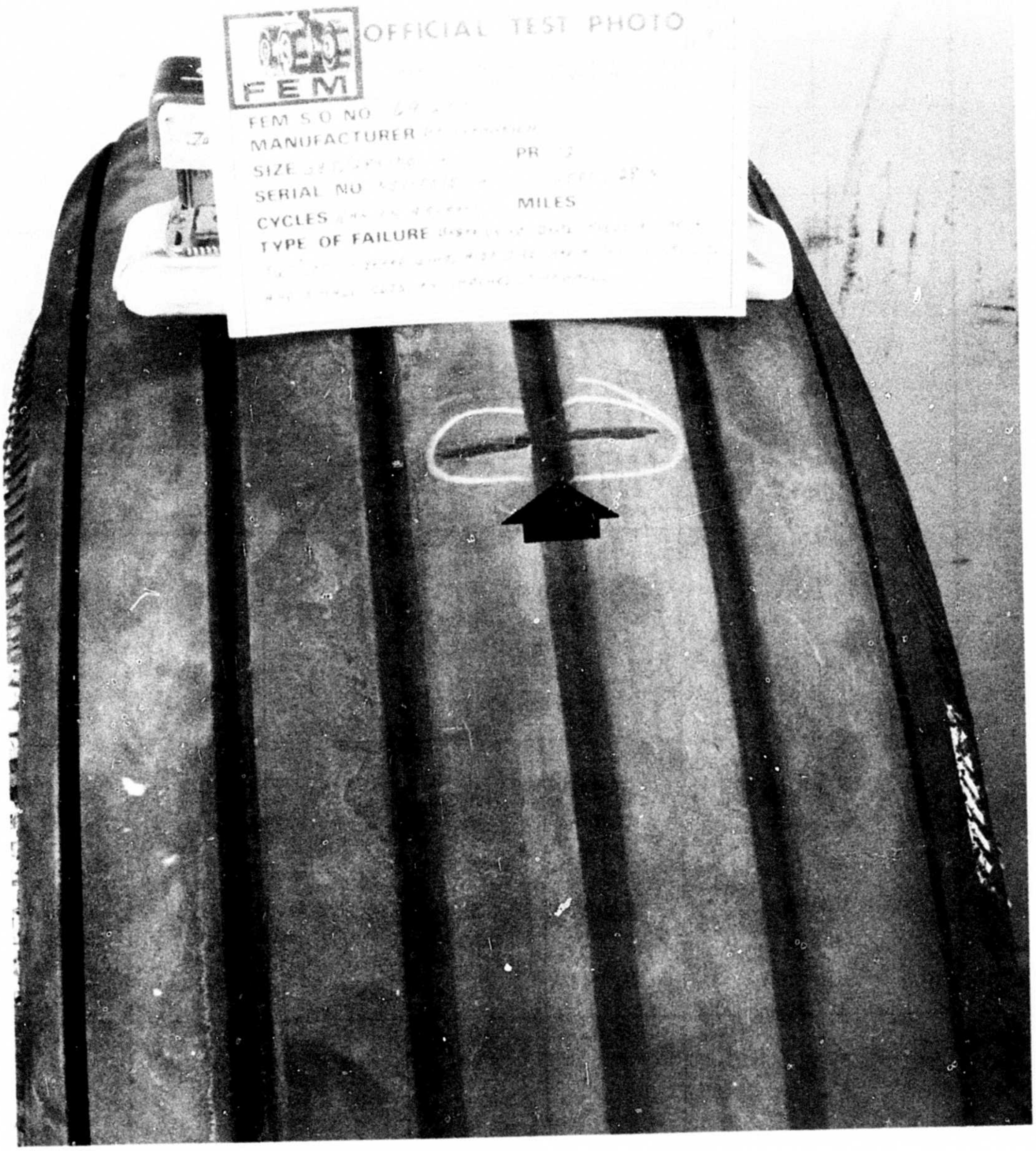


Figure 24. Tread Cut On Tire No N51-0035-16.

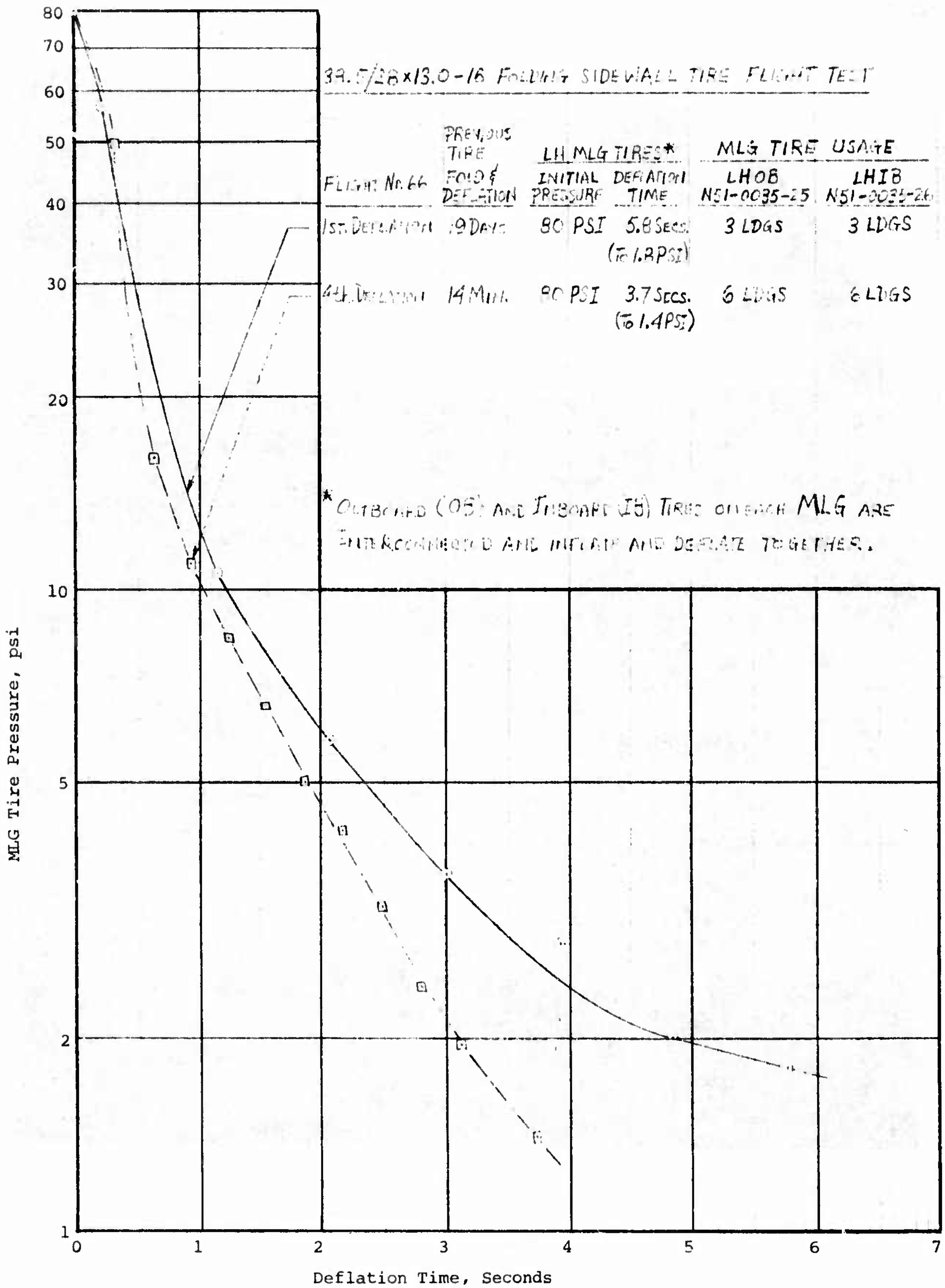


Figure 25. Ti[illegible] Deflation Time Histories-Flight 66.

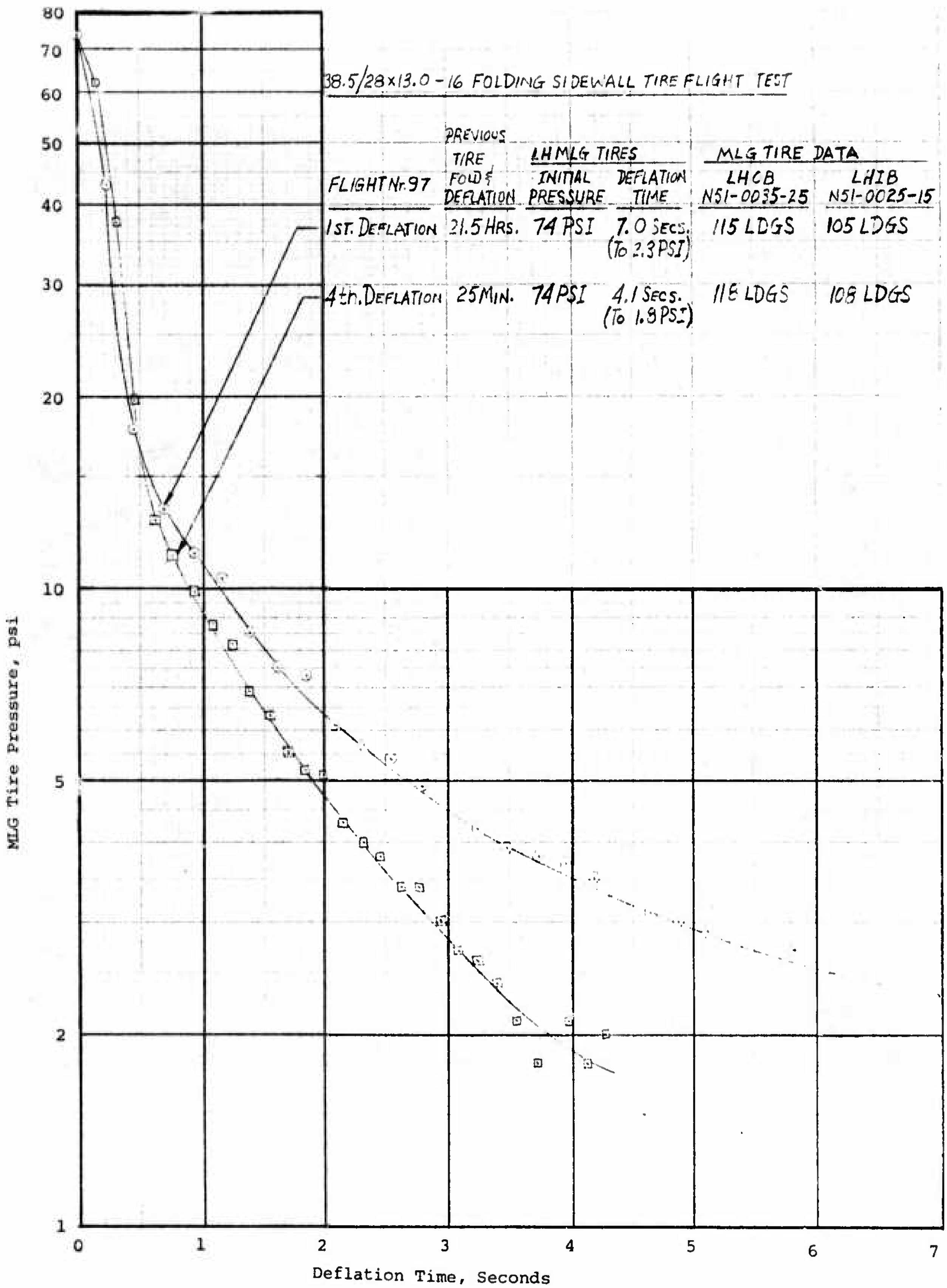


Figure 26. Tire Deflation Time Histories-Flight 97.

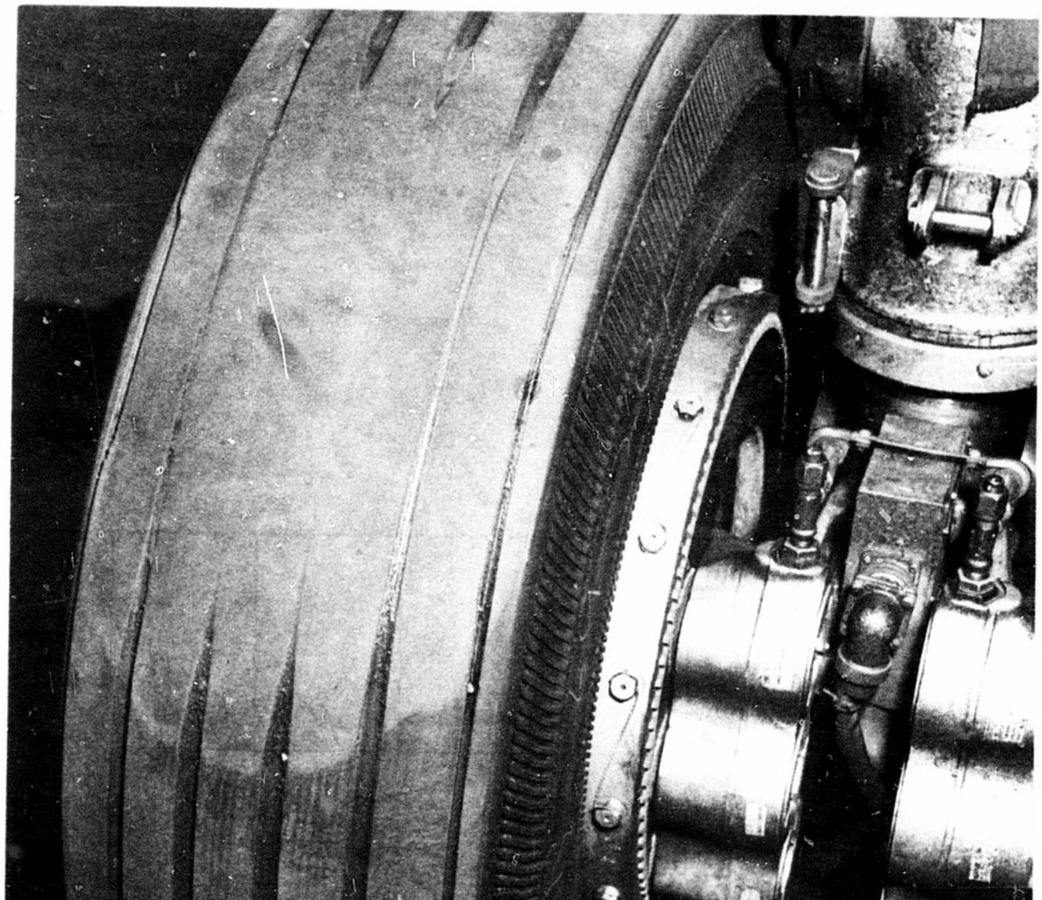

Figure 27. Flat Spot On Tire No N51-0023-19 Due To Excessive Braking.

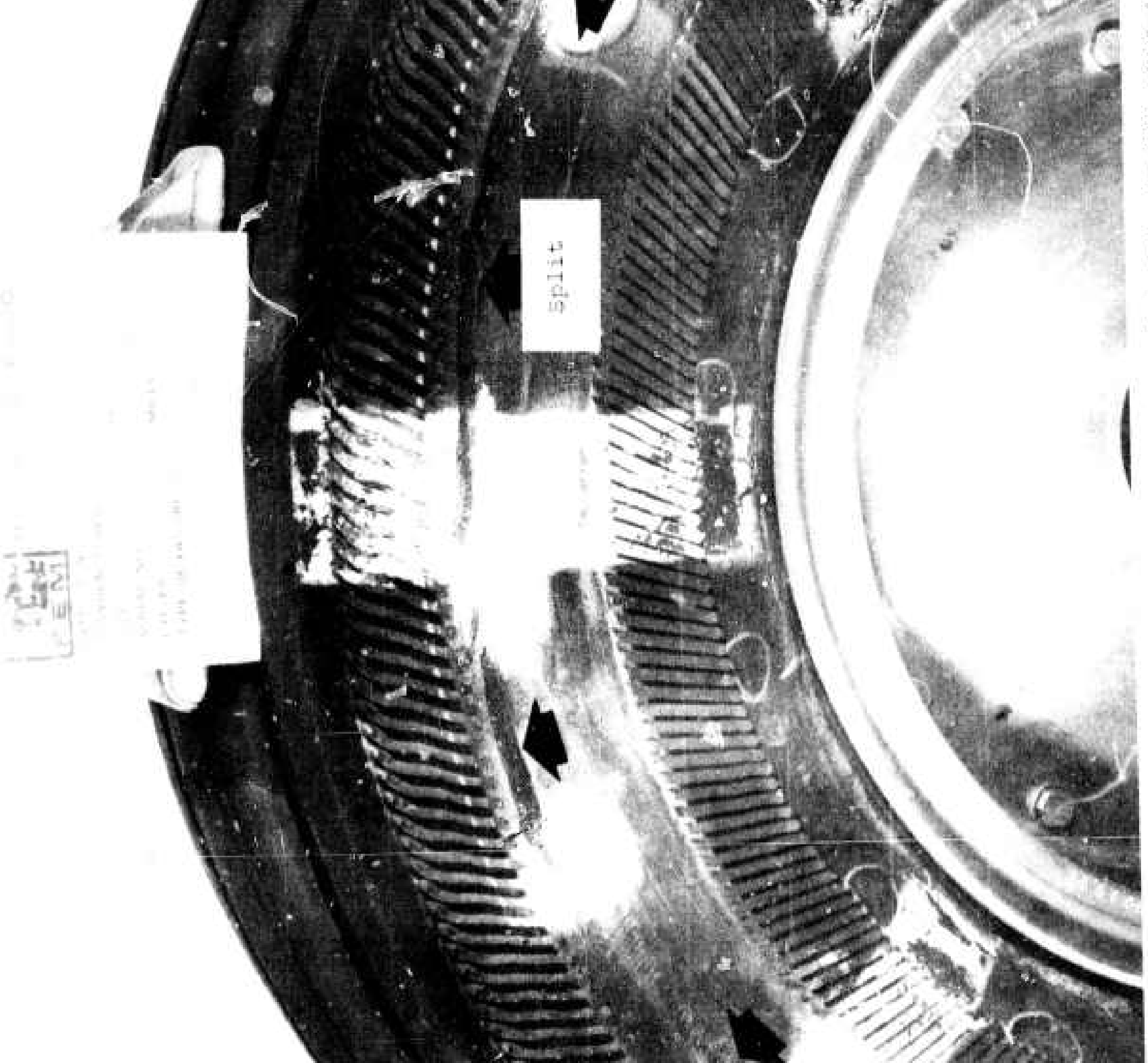


Figure 28. Sidewall Split, Exposing Outer Layer Of Cord On Tire No N51-0035-16.

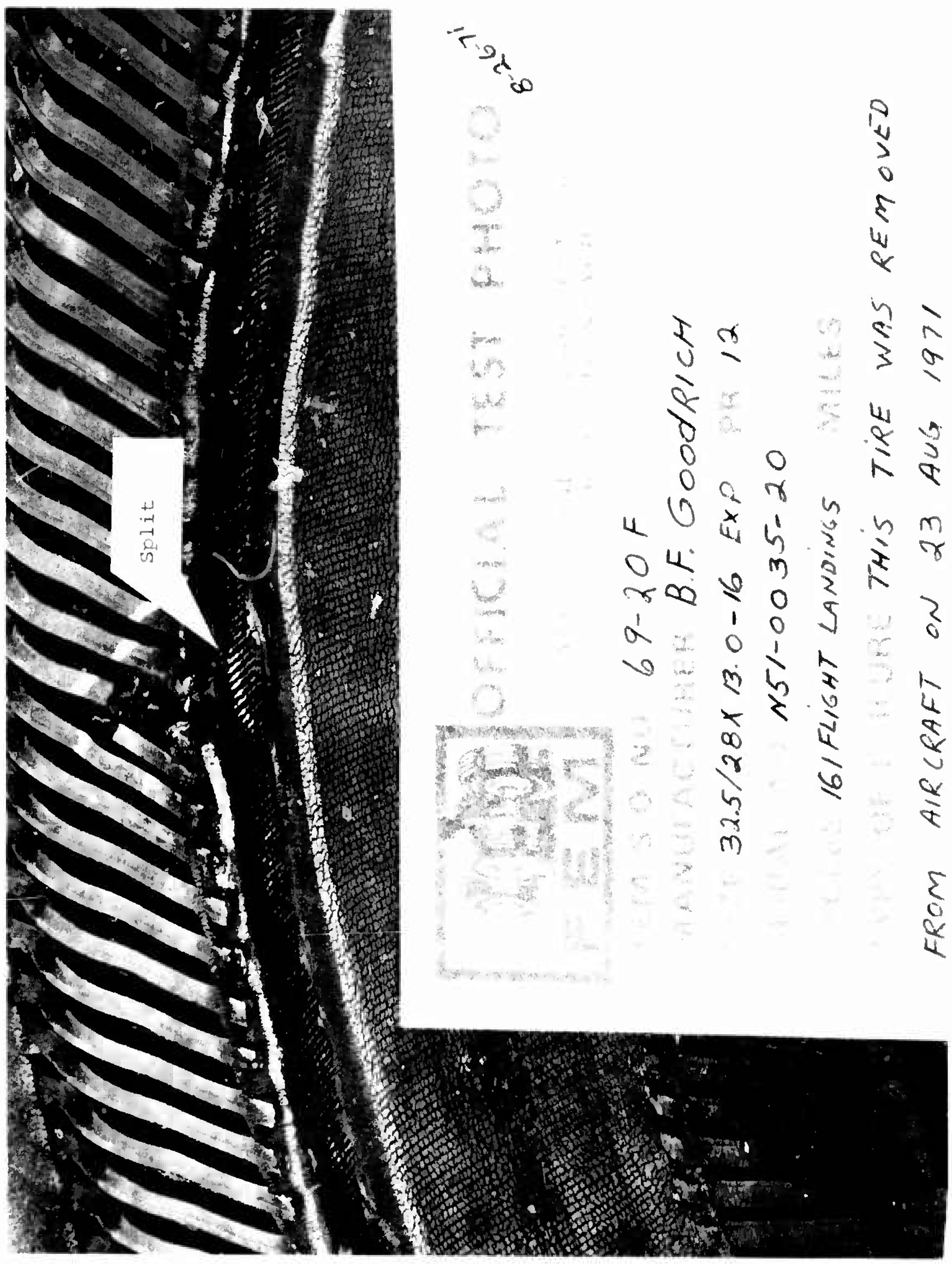


Figure 29. Sidewall Surface Split On Tire No N51-0035-20.

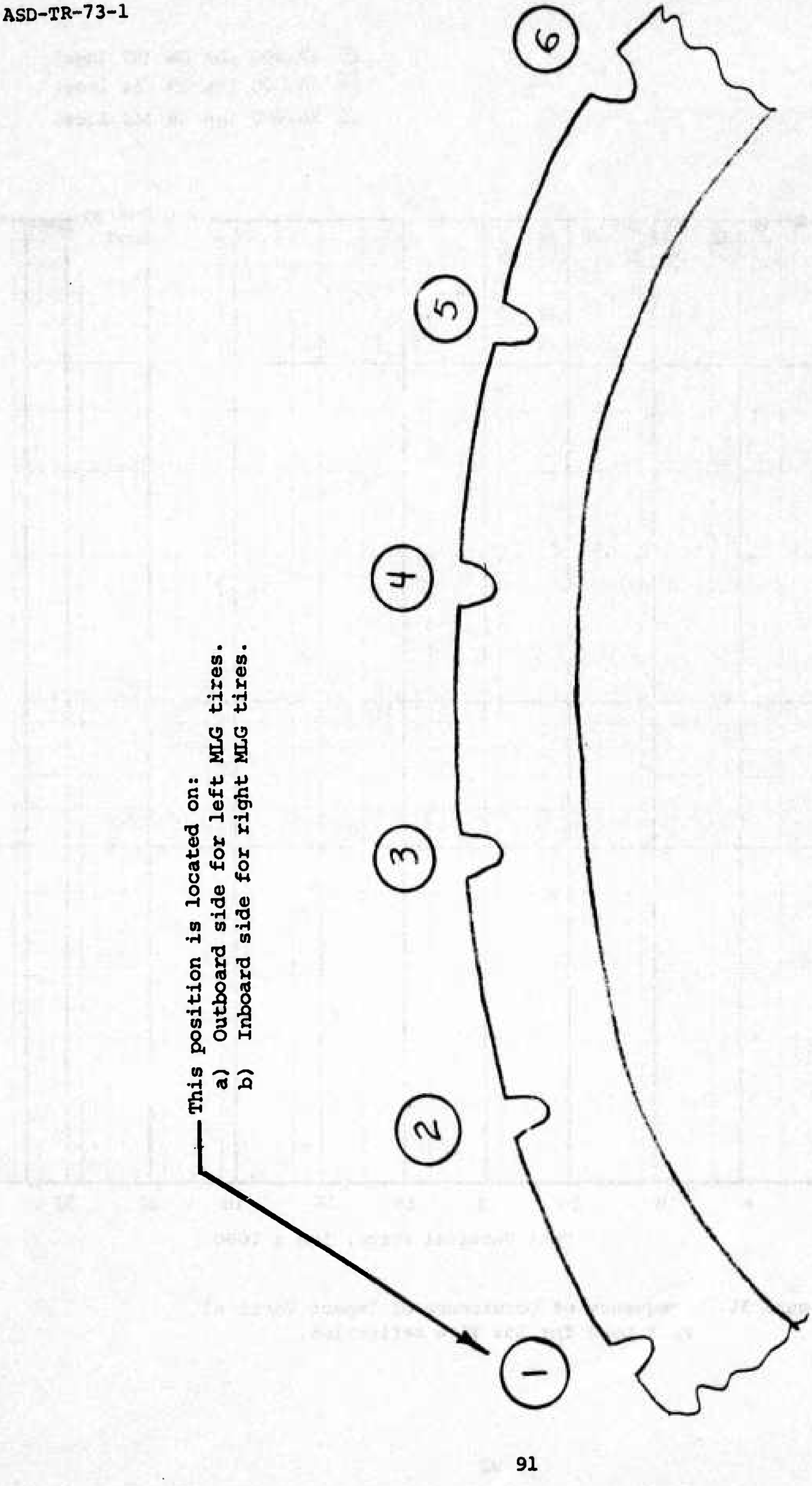


Figure 30. Tire Tread Groove Positions.

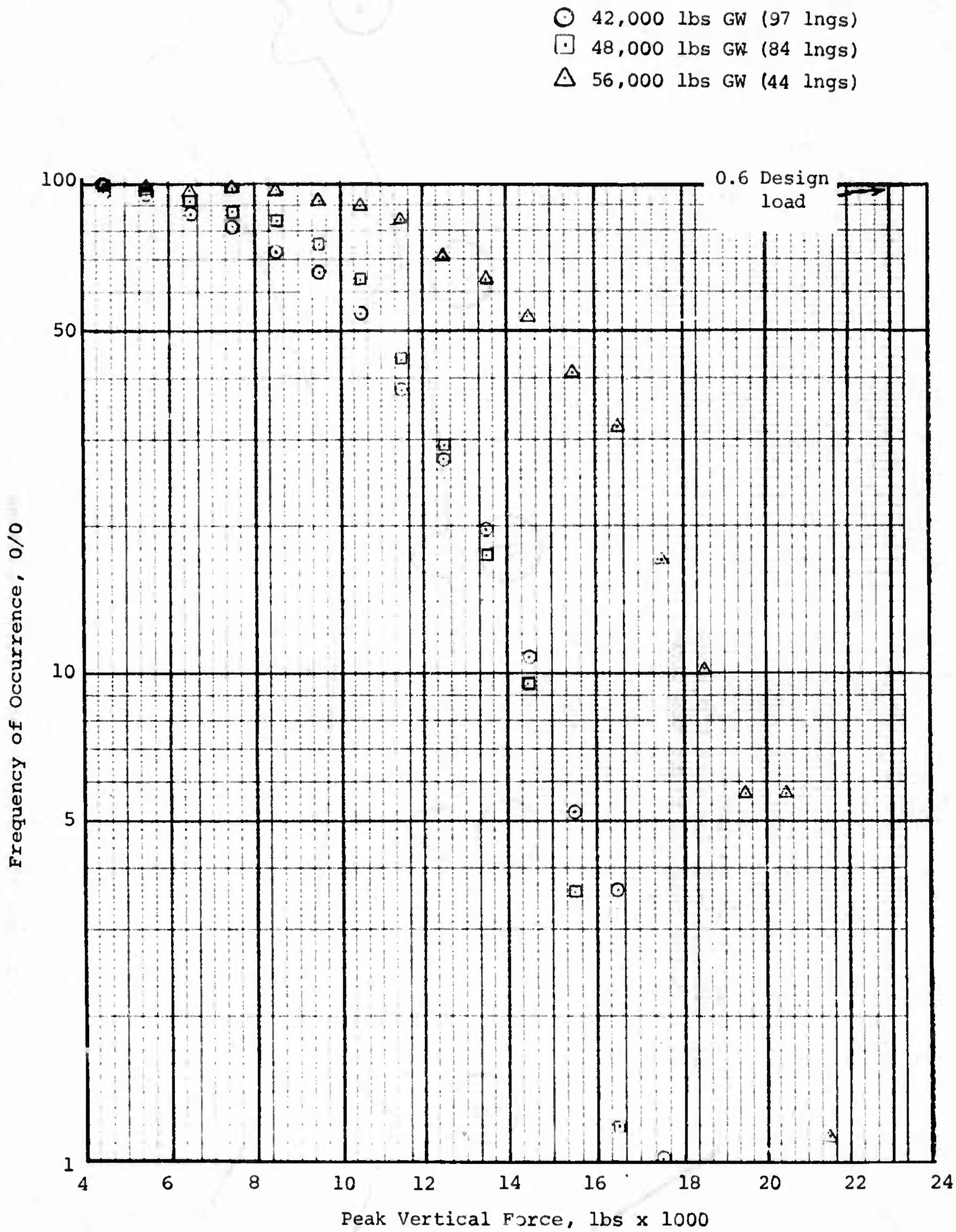


Figure 31. Frequency of Occurrence of Impact Vertical Peak Load for 35% Tire Deflection.

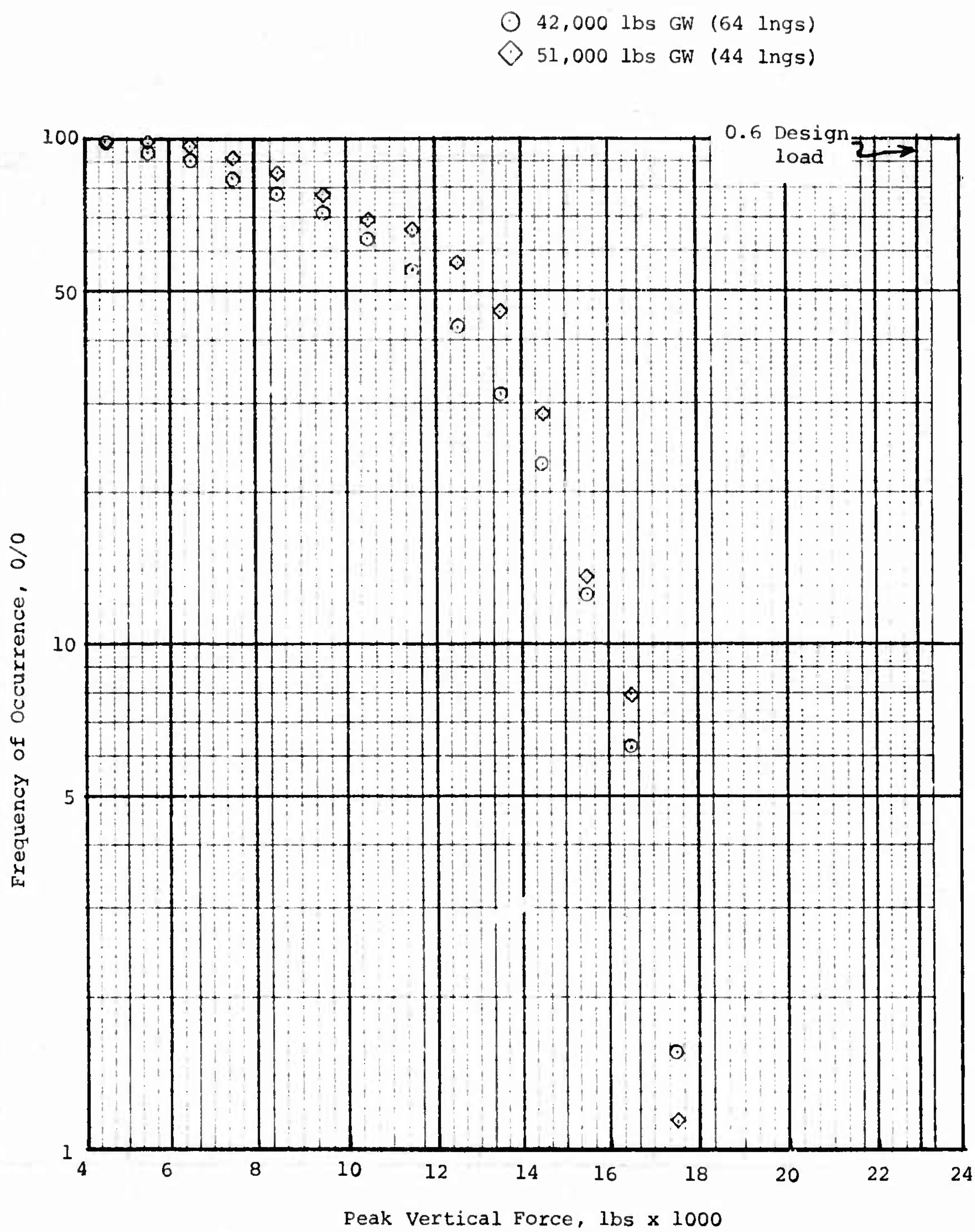


Figure 32. Frequency of Occurrence of Impact Vertical Peak Load for 50% Tire Deflection.

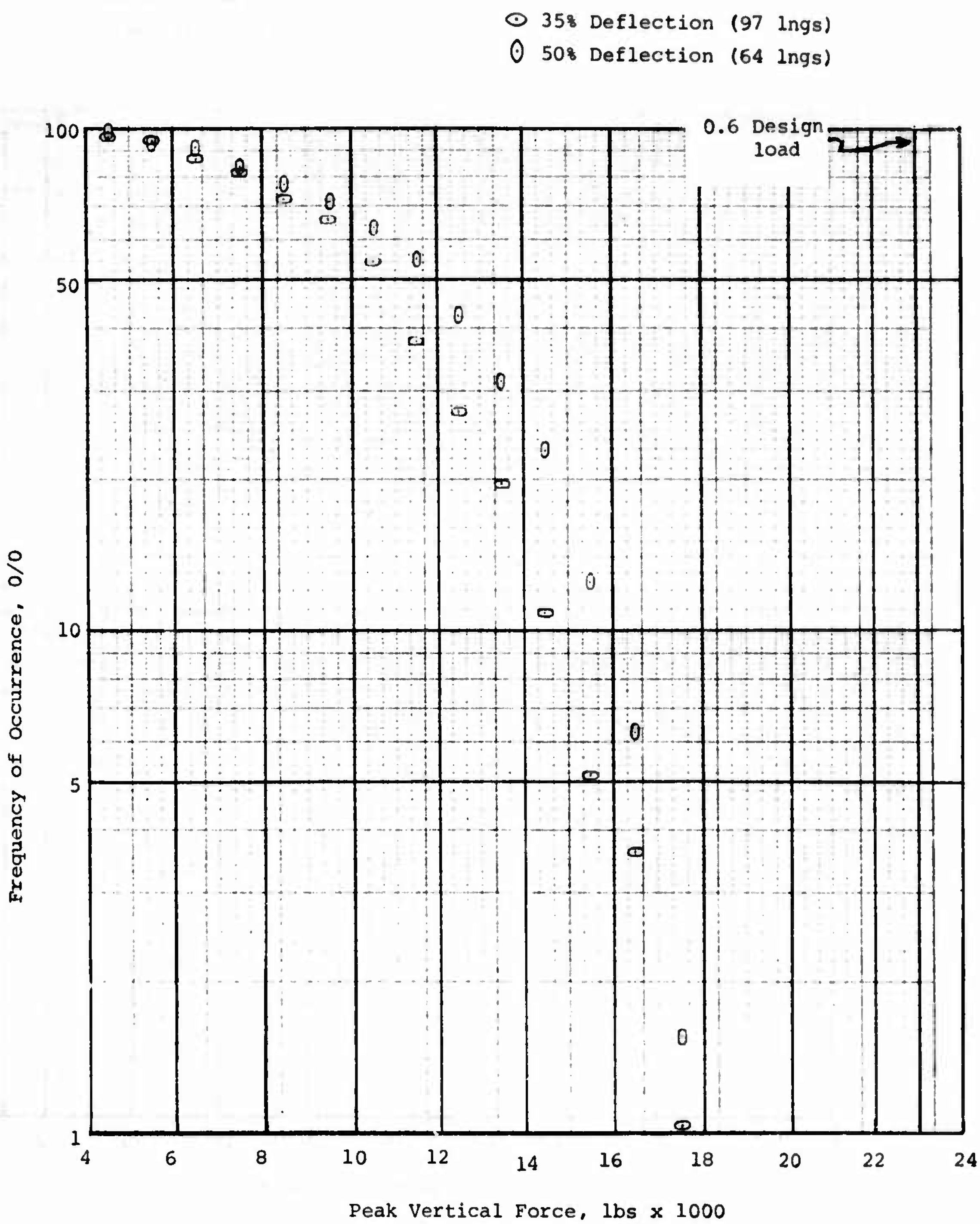


Figure 33. Frequency of Occurrence of Impact Vertical Peak Load at 42,000 lbs Ramp Weight for both 35% and 50% Tire Deflection.

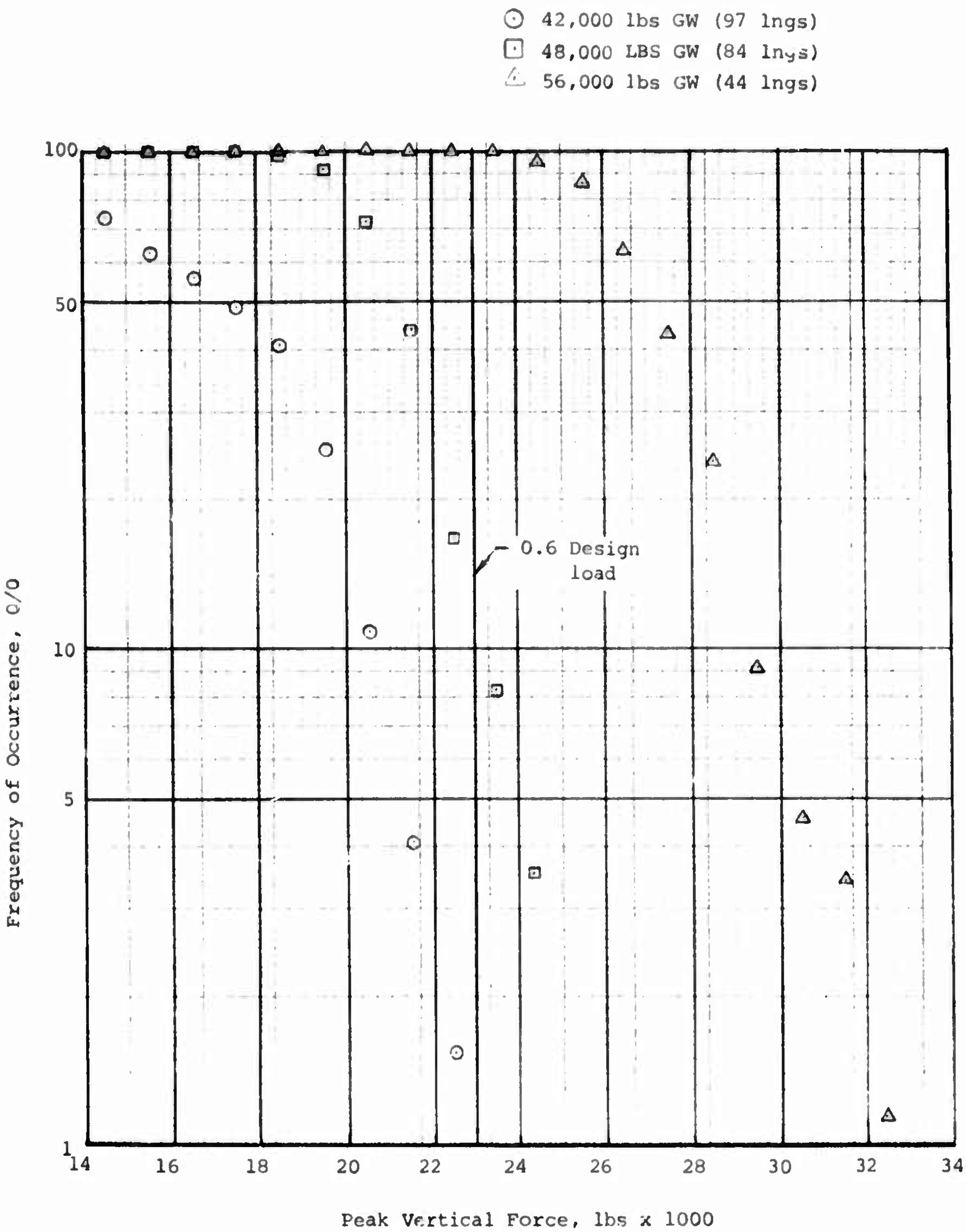


Figure 34. Frequency of Occurrence of Overall Vertical Peak Load at 35% Tire Deflection.

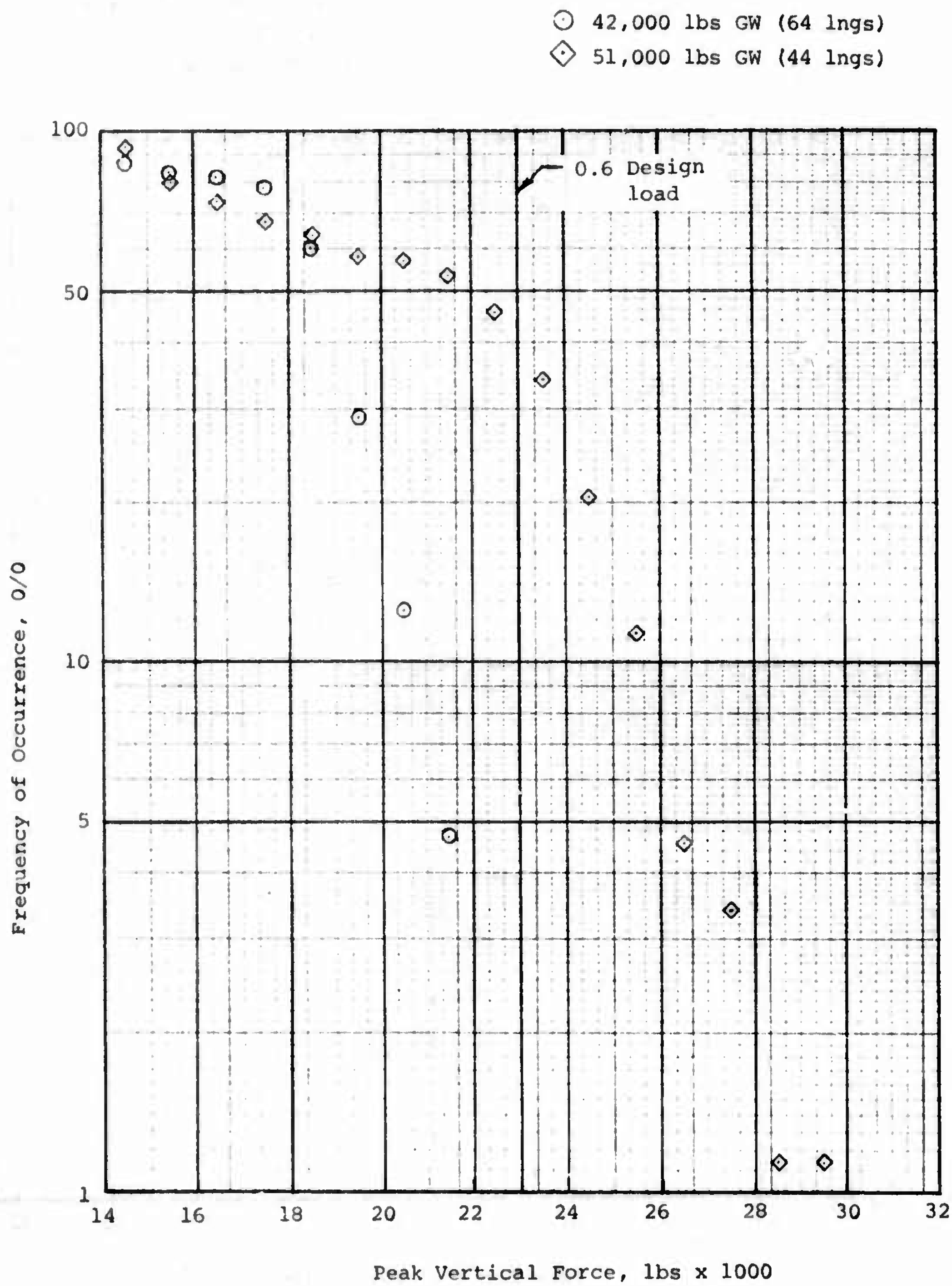


Figure 35. Frequency of Occurrence of Overall Vertical Peak Load at 50% Tire Deflection.

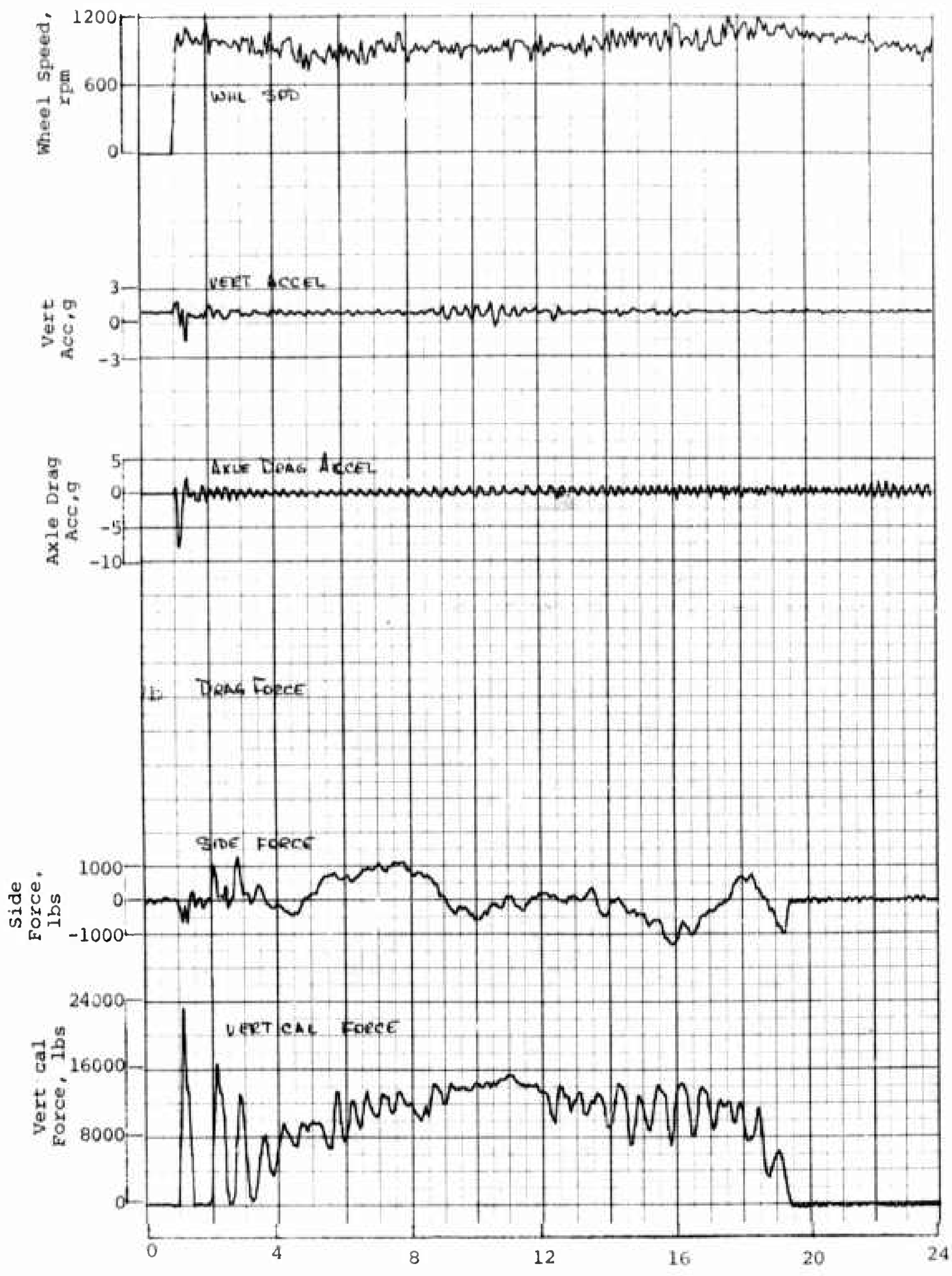


Figure 36a. Time History Of Landing Number 3 Of Flight 98 For Left Main Landing Gear.

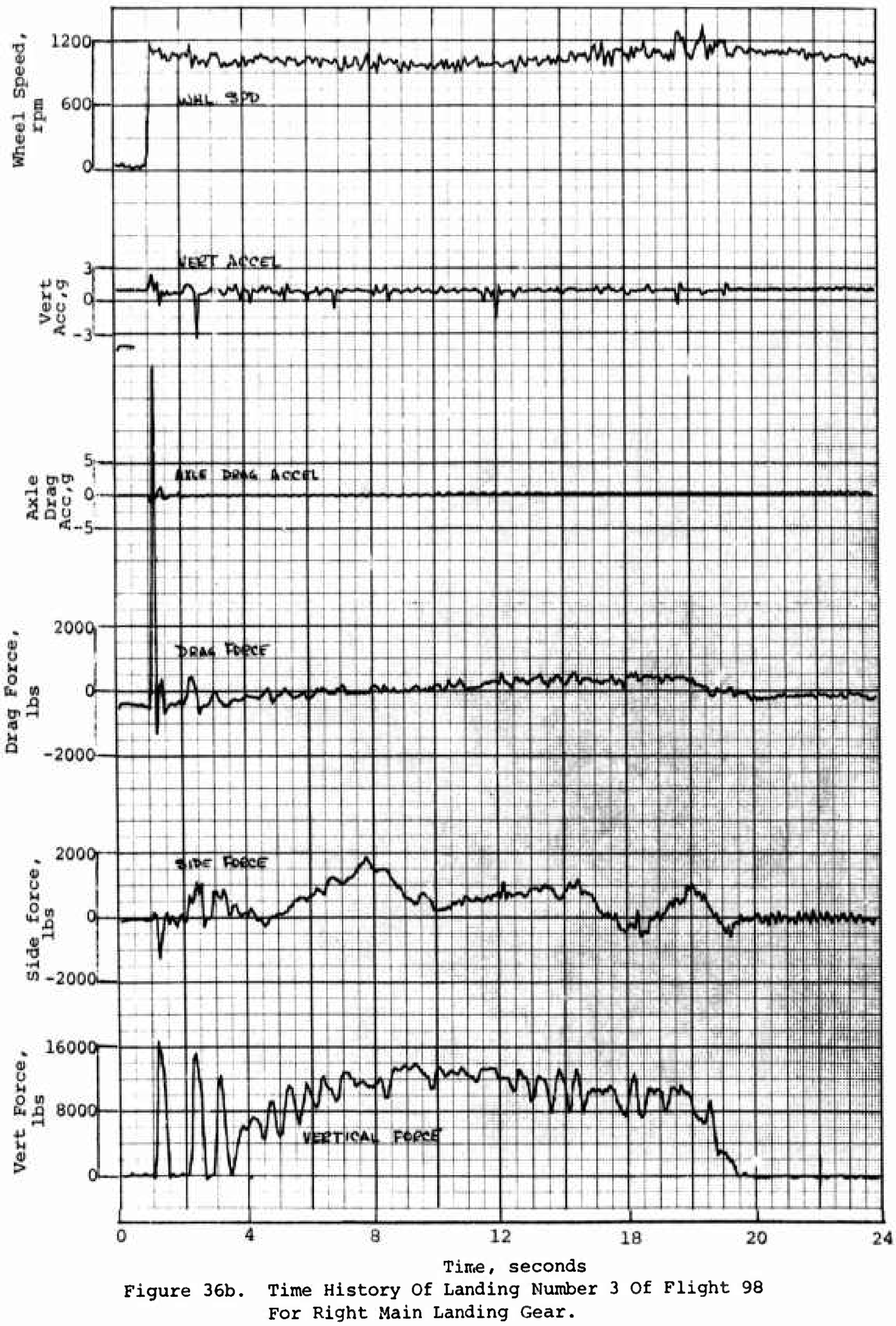


Figure 36b. Time History Of Landing Number 3 Of Flight 98 For Right Main Landing Gear.

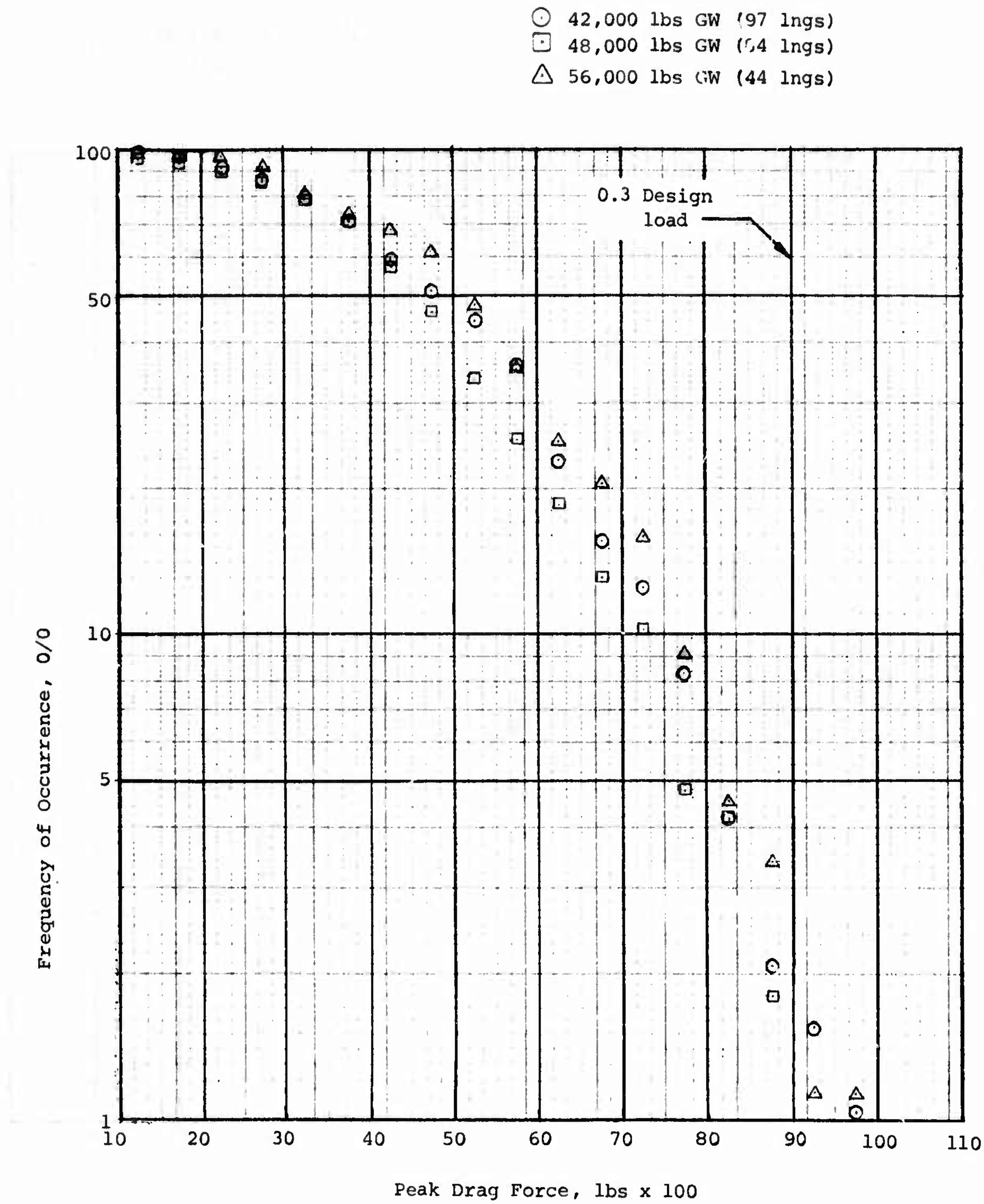


Figure 37. Frequency of Occurrence of Impact Drag Peak Load at 35% Tire Deflection.

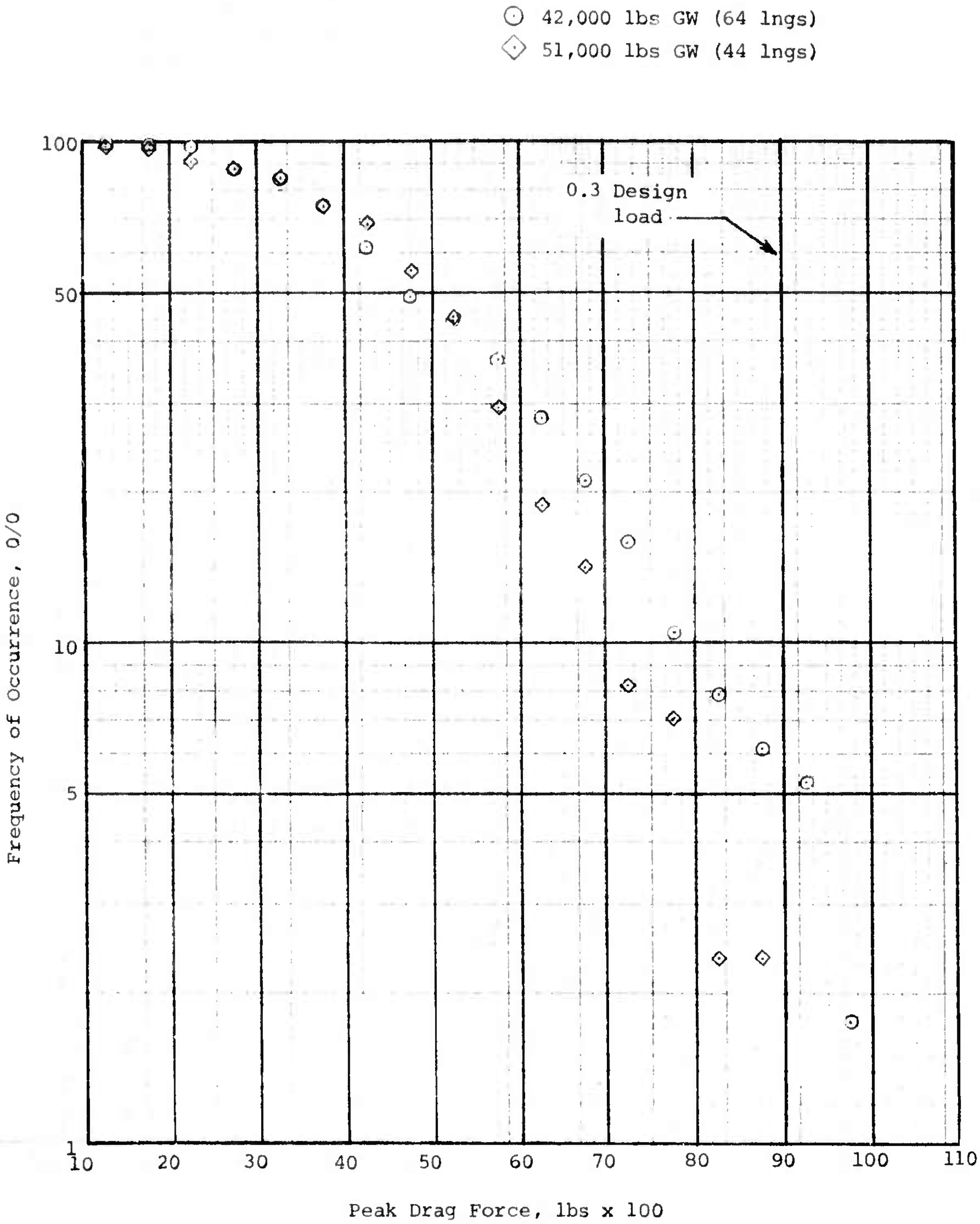


Figure 38. Frequency of Occurrence of Impact Drag Peak Load at 50% Tire Deflection.

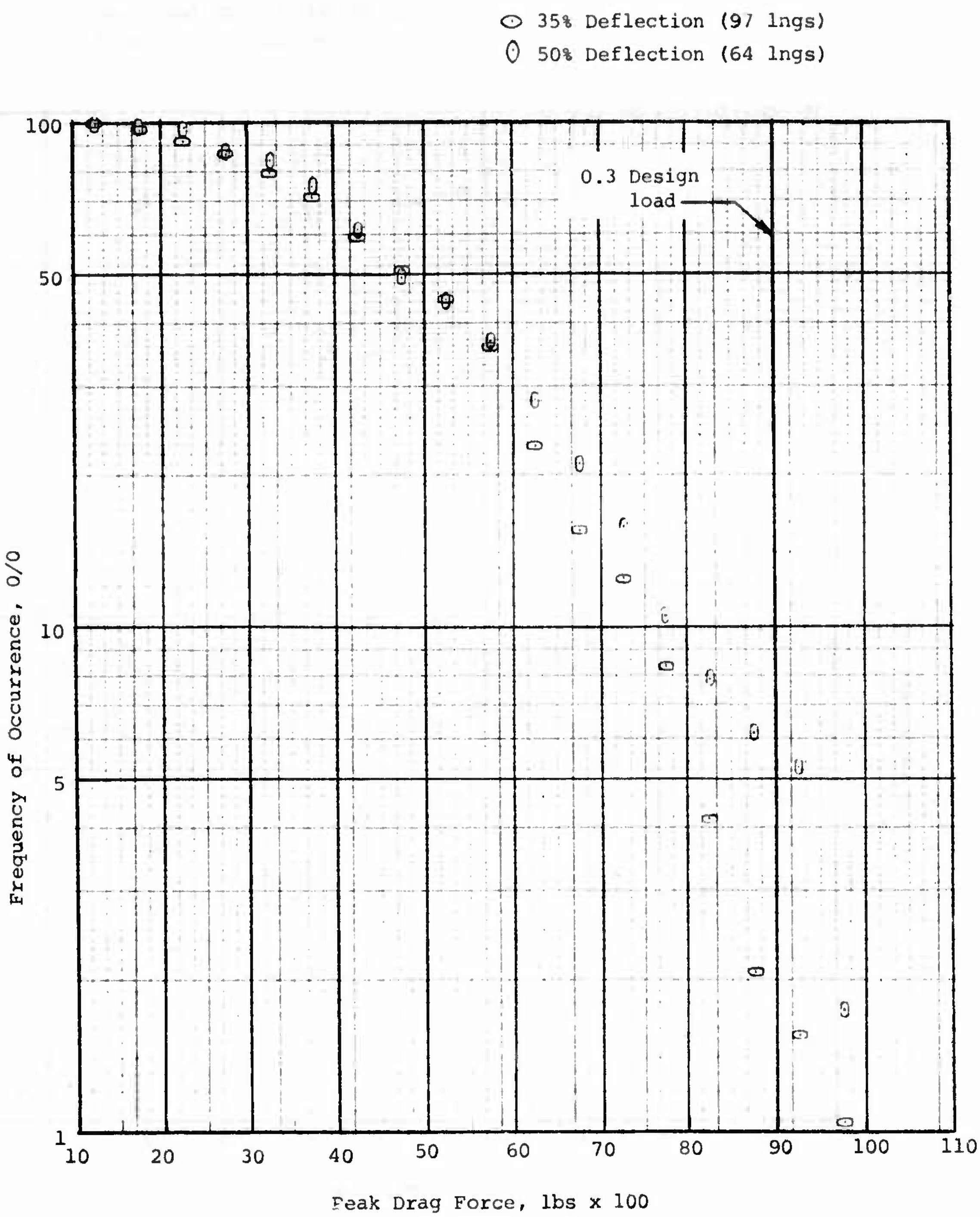


Figure 39. Frequency of Occurrence of Impact Drag Peak Load at 42,000 lbs Ramp Weight for both 35% & 50% Tire Deflection.

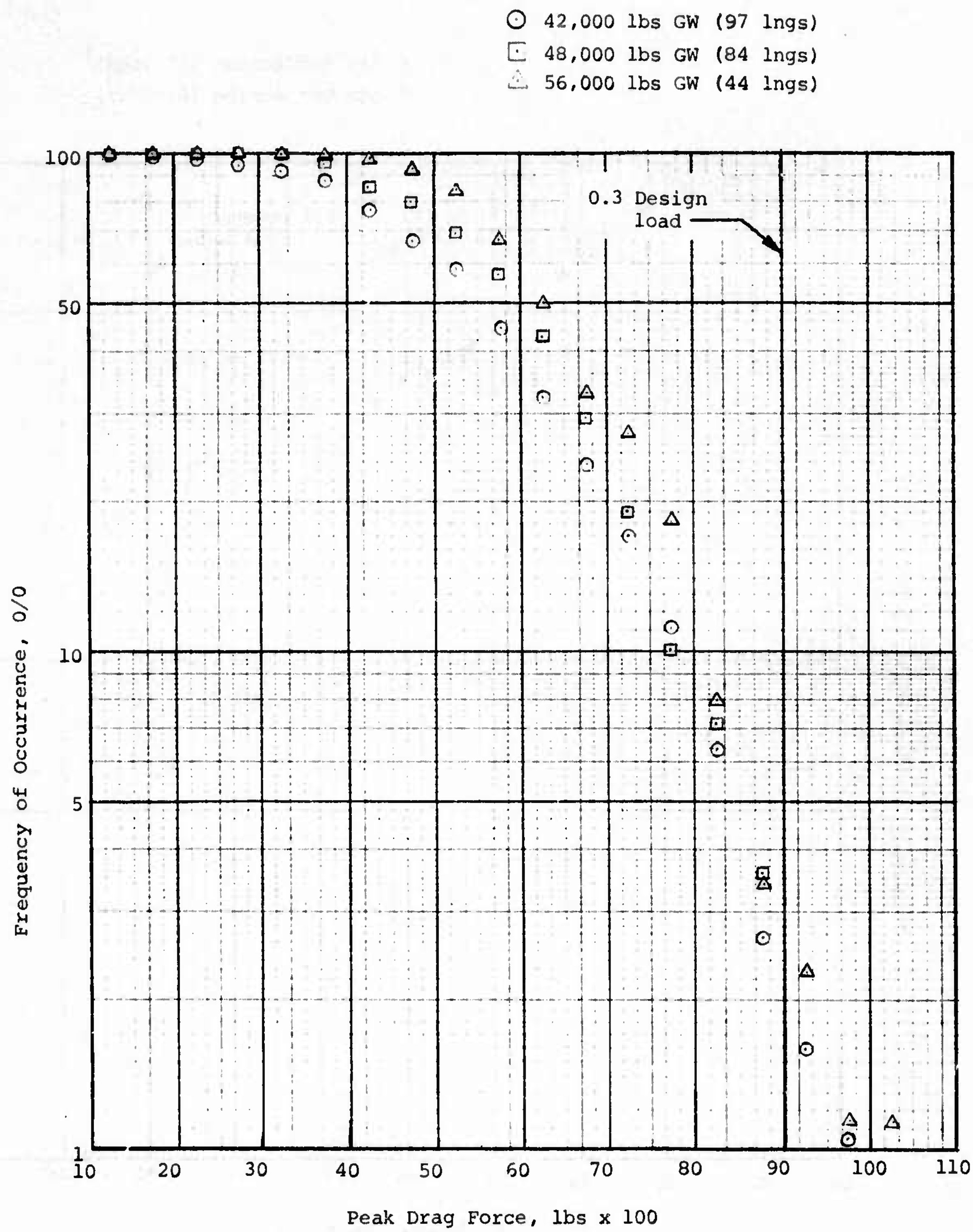


Figure 40. Frequency of Occurrence of Overall Drag Peak Load at 35% Tire Deflection.

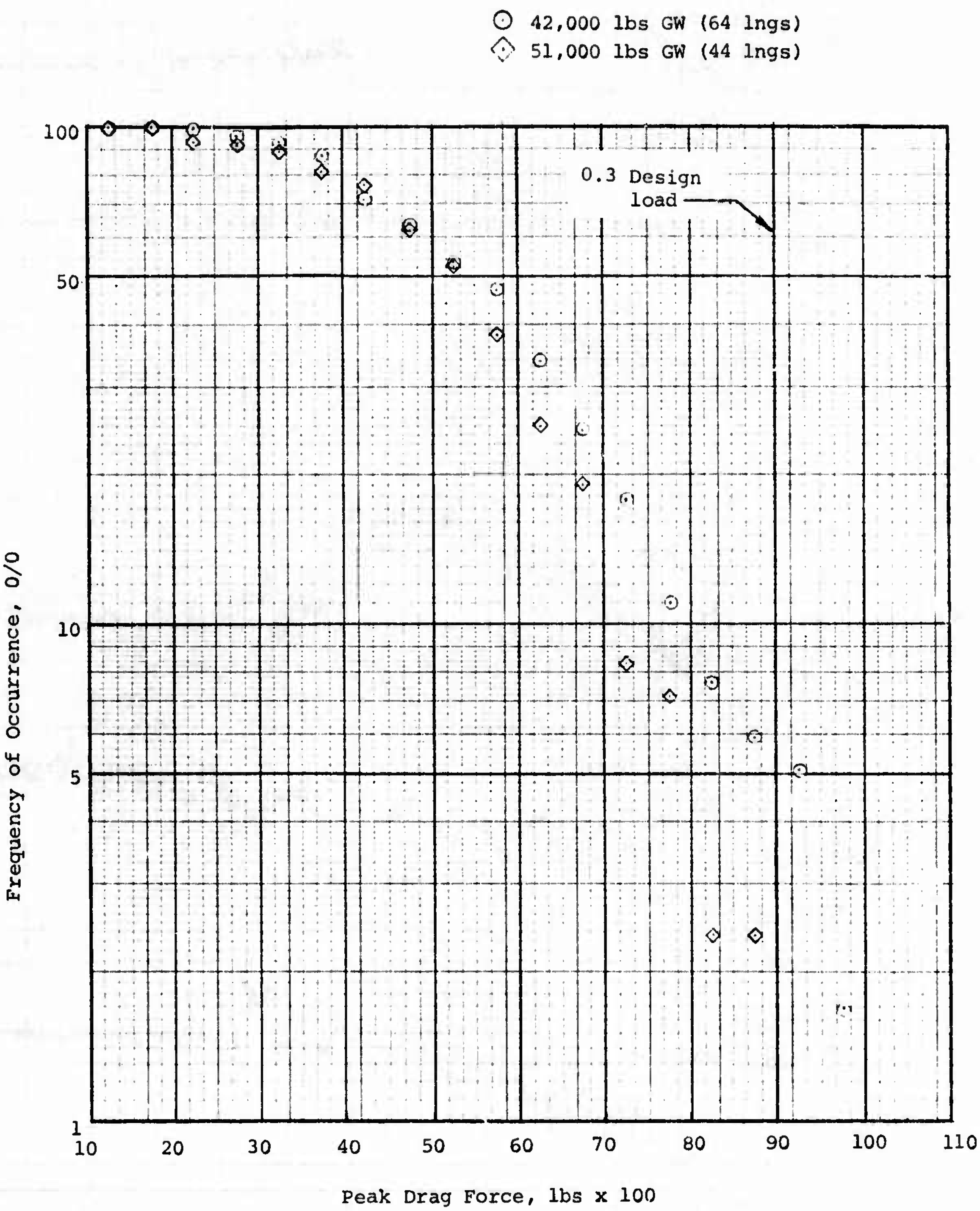


Figure 41. Frequency of Occurrence of Overall Drag Peak Load at 50% Tire Deflection.

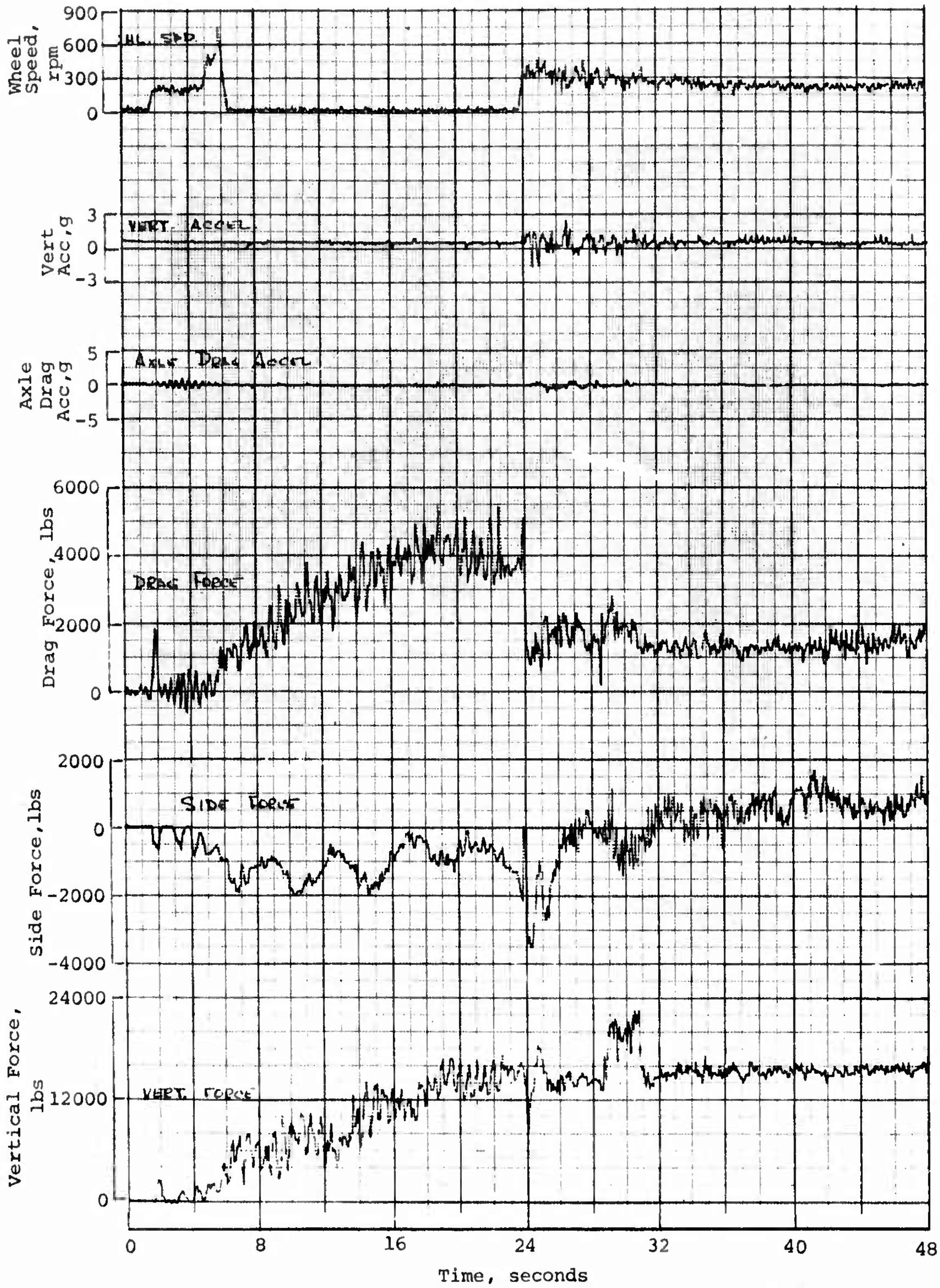


Figure 42a. Time History Of Landing Number 4 Of Flight 25
For Left Main Landing Gear.

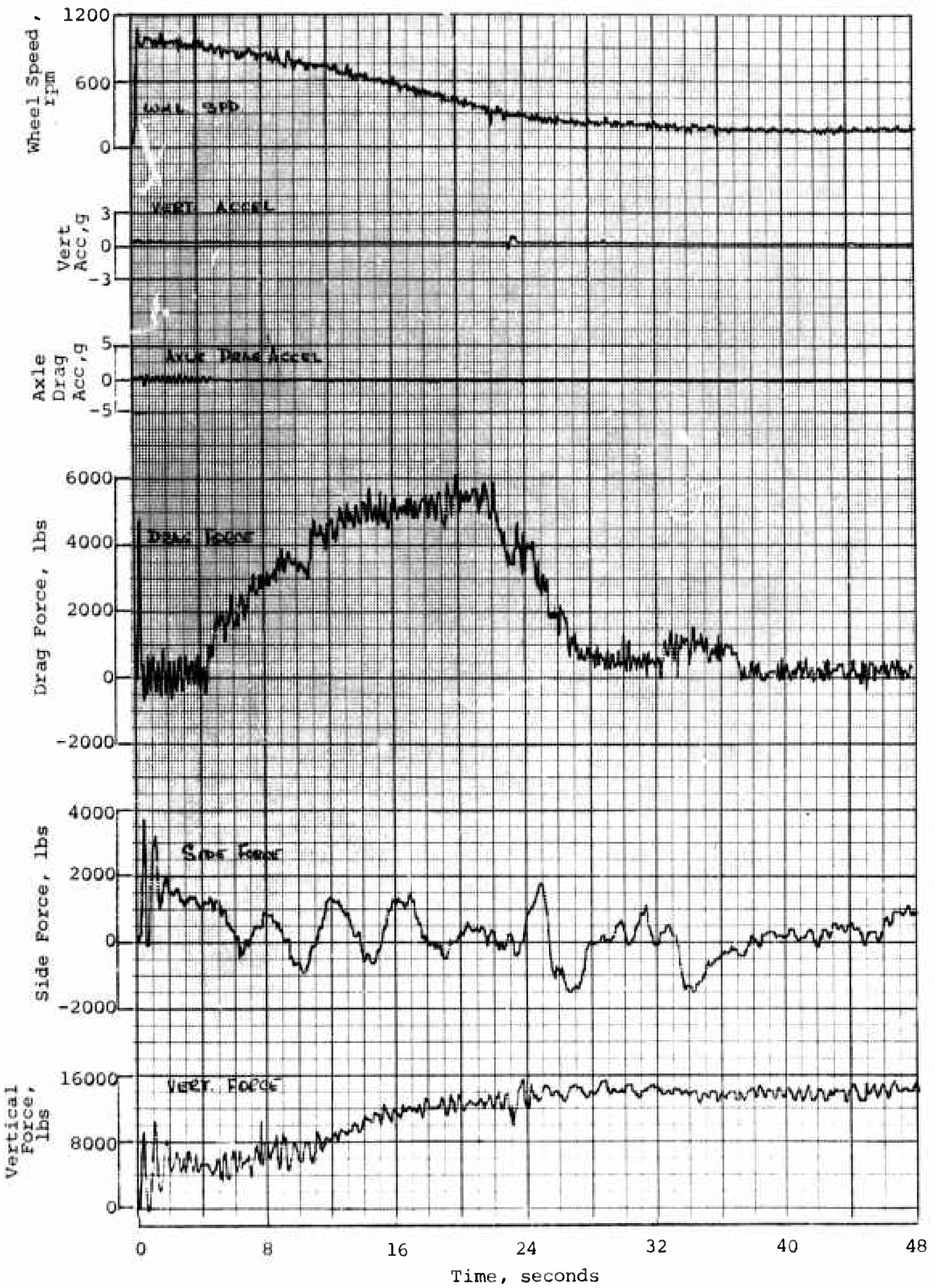


Figure 42b. Time History Of Landing Number 4 Of Flight 25
For Right Main Landing Gear.

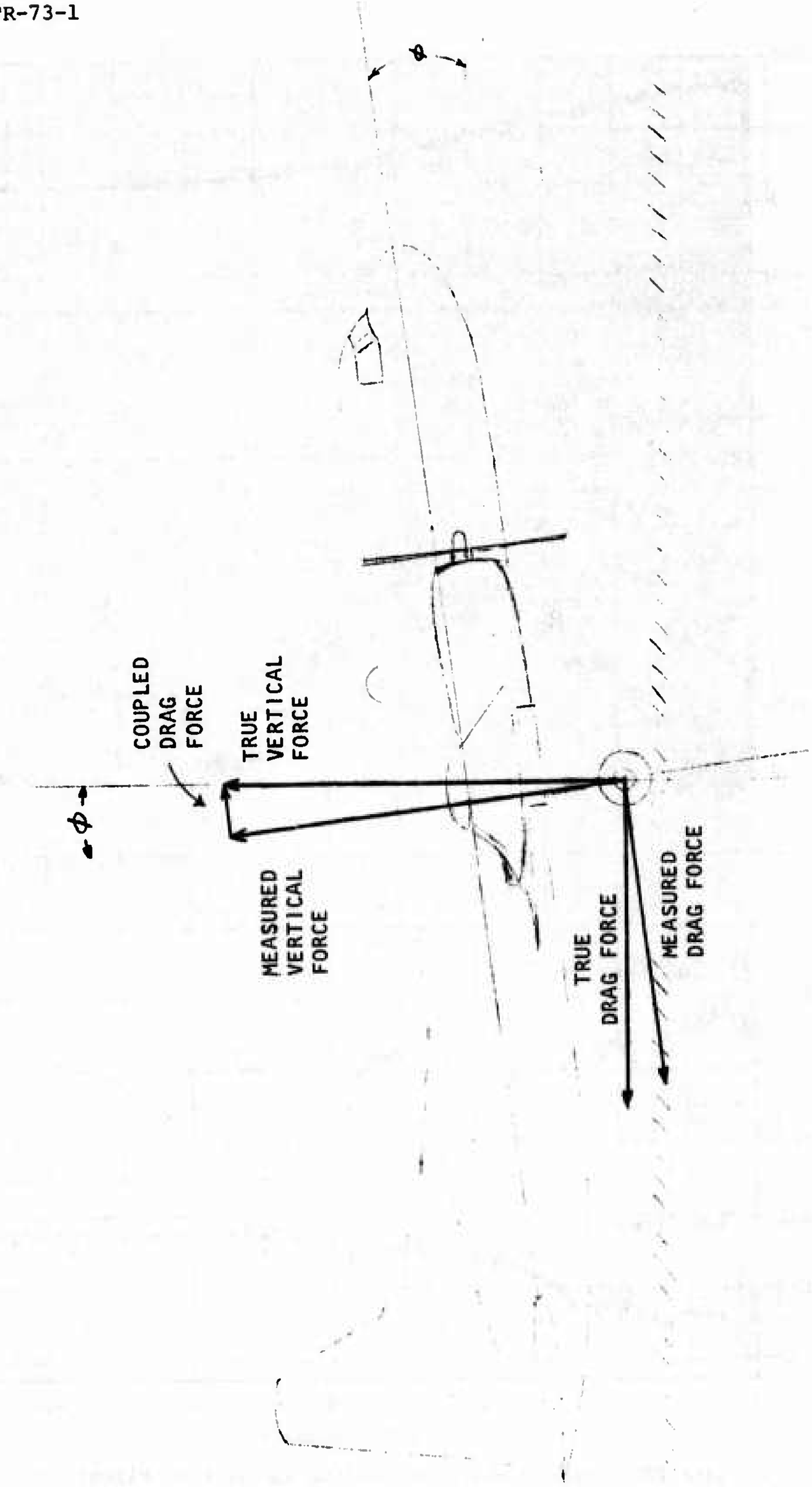


Figure 43. Vector Diagram Showing Effect Of Aircraft Pitch Attitude On The Magnitude Of The Measured Forces.

TABLE I

GENERAL DESIGN AND CONSTRUCTION(1)

| Item | Requirement | Qualification Results |
|---|---|---|
| Balance | 35 oz-in. | 40 oz-in. |
| Bead seating press. | Max 75 psi<br>Min 25 psi | 30-35 psi |
| Bead width | Max 1.90 in. | 1.77 in. |
| Burst press. | Min 300 psi | 320 crown psi |
| Deflection | Load ___ lb, defl ___ %<br>Press. ___ psi | Load ___ lb, defl ___ %<br>Press. ___ psi |
| Dimensions | | |
| (A) OD | Max 38.44 in., min 37.09 in. | 37.90 in. |
| (B) Sect. width | Max ___ in., min ___ in. | 12.50 in. |
| (C) Shldr. dia. | Max ___ in. | ___ in. |
| (D) Shldr. width | Max ___ in. | ___ in. |
| (Refer to MIL-T-5041, A, B, C, D of Tables X-XVIII | | ___ in. |
| Mold skid depth | Min .45 in. | 0.450 in. |
| Total tread thickness | Min .60 in. | 0.60 in. |
| Weight | Max ___ lb | Actual 83.0 lb |
| Dynamic test result | Calculated max wt | ___ lb |
| Air retention (tubeless) | Max 5.0% loss | .06 % |
| Strength of union | | |
| Between sidewall & plies | (as determined)(2) | ___ lb |
| Between tread & plies | (as determined) | ___ lb |
| No. of wires per bead bndl. | (as determined) | 1st 64<br>2nd 80<br>3rd ___<br>4th ___ |
| Chafing strips | (as determined) | One |
| Bead tie-in | | |
| Heel ply turn-ups | (as determined) | No. 4 |
| Toe ply turn-ups | (as determined) | No. 4 |
| Flippers per bead bndl. | (as determined) | No. 1 |
| Min. tensile of cord | (as determined) | 28 lb |
| Cord count in crown (meas. @ 90° angle to cord path) | (as determined) | Plies / Count<br>1-8 / 33<br>OH 1&2 / 26 |
| Total crown thickness | (as determined) | 1.0 in. |
| No. of breaker plies | (as determined) | 2 |
| No. of tread reinforcement plies | (as determined) | ___ |
| Sidewall vents per side | (as determined) | No. 16 Type Awl |
| Durometer hardness (shore rubber tread only) | (as determined) | 63 |
| Inside crown diameter | (as determined) | ___ in. |
| Inside toe-to-toe peripheral dim. | (as determined) | ___ in. |
| Toe-to-toe diameter | (as determined) | 15.55 in. |

NOTES:

(1) Tire size, 38.5/28 x 13.0-16; type, folding sidewall; no. plies, 10; cord mat'l, nylon 840/2; tire ply rating, 12; approved low temp., -65°F; tread design, rib.

(2) The term "as determined" as used above denotes that the value shall be determined and reported even though requirements are not specified for such values.

TABLE II. SUMMARY OF THE VARIOUS FLIGHT SEQUENCES.

| Flight Sequence | Flight Test Dates | Ground Roll Per Flight Sequence (miles) | Tire Inflation Pressure (psi) | Number of Landings During Flight Sequence: A/C GR WT | | | Type Landing | | Braking Technique | | | | Tire Deflection | | Surface Condition | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | M | H | BS | T&G | L | M | H | W/R | 35% | 50% | Dry | Wet |
| 49-57 | 21 Oct-7 Dec 70 | 95.6 | 80 | | | 25 | 25 | | 16 | 9 | | 25 | 25 | | 22 | 3 |
| 65-72 | 31 Mar-13 May 71 | 100.2 | 80 | | | 20 | 20 | | 20 | | | 20 | 20 | | 19 | 1 |
| 94-97 | 22-27 Jul 71 | 40.5 | 60-72 | | | 12 | 12 | | 12 | | | 12 | 12 | | 12 | |
| 102-106 | 5-12 Aug 71 | 50.0 | 44 | | | 16 | 16 | | 16 | | | 16 | | 16 | 16 | |
| 107-108 | 10 Sept 71 | 22.8 | 70 | | | 24 | 2 | 22 | 2 | | | 2 | 24 | | 24 | |
| 109-110 | 13-14 Sept 71 | 17.1 | 44 | | | 22 | 2 | 20 | 2 | | | 2 | | 22 | 22 | |
| 111-115 | 15-17 Sept 71 | 43.2 | 44 & 70 | | | 32 | 10 | 22 | 10 | | | 10 | 24 | 8 | 32 | |
| 34-48 | 5 Aug-13 Oct 70 | 114.2 | 72 | 4 | 55 | | 59 | | 25 | 34 | | 58 | 59 | | 58 | 1 |
| 58-64 | 9 Dec 70-1 Mar 71 | 58.0 | 72 | | 30 | | 30 | | 19 | 11 | | 30 | 30 | | 13 | 17 |
| 1-15 | 17 Mar-22 May 70 | 80.5 | 60 | 41 | | | 41 | | 10 | 26 | 5 | 13 | 41 | | 32 | 9 |
| 16-25 | 1 Jun-8 Jul 70 | 61.1 | 60 | 35 | | | 35 | | 2 | 14 | 19 | 1 | 35 | | 30 | 5 |
| 26-33 | 20-31 Jul 70 | 51.4 | 60 | 30 | | | 30 | | 1 | 29 | | 30 | 30 | | 29 | 1 |
| 73-89 | 17 May-13 Jul 71 | 97.9 | 36 | 48 | | | 48 | | 48 | | | 48 | | 48 | 47 | 1 |
| 90-93 | 15-20 Jul 71 | 28.4 | 60 | 39 | | | 4 | 35 | 4 | | | 4 | 39 | | 39 | |
| 98-101 | 29 Jul-3 Aug 71 | 26.7 | 36 | 26 | | | 4 | 22 | 4 | | | 4 | 10 | 16 | 24 | 2 |
| Totals | | 887.6 | | 223 | 85 | 151 | 338 | 121 | 191 | 123 | 24 | 275 | 349 | 110 | 419 | 40 |

GROSS WEIGHT:

L = Light = 41,300 to 42,600 lbs
M = Medium = 47,200 to 49,575 lbs
H = Heavy = 51,171 to 56,665 lbs

BRAKING TECHNIQUE:

L = Light M = Moderate H = Heavy
W/R = with reverse pitch

TYPE LANDING:

BS = Braked Stop
T & G = Touch And Go

TABLE III. TIRE SUMMARY. FLIGHT TEST FOR 38.5/28x13.0-16 FOLDING SIDEWALL TIRES.

| Tire Code No. | Tire Serial No. | MLG Tire Position | Test Duration | | Accum. Ground Run Miles | No. of Land'gs |
|---|---|---|---|---|---|---|
| | | | Flights | Date | | |
| 11-N | N51-0023-5 | Right Inb'd | 1 thru 15 | 16 Mar-22 May 70 | 80.5 | 41 |
| 12-N | N51-0023-7 | Left Outb'd | 1 thru 15 | 16 Mar-22 May 70 | 80.5 | 41 |
| 14-N | N51-0023-18 | Left Inb'd | 1 thru 15 | 16 Mar-22 May 70 | 80.5 | 41 |
| 15-N | N51-0023-19 | Right Outb'd | 1 thru 15 | 16 Mar-22 May 70 | 80.5 | 41 |
| 32-N | N51-0035-11 | Left Outb'd | 16 thru 25 | 1 Jun-08 Jul 70 | 61.1 | 35 |
| 34-N | N51-0035-14 | Left Inb'd | 16 thru 25 | 1 Jun-08 Jul 70 | 61.1 | 35 |
| 31-N | N51-0035-9 | Right Inb'd | 16 thru 64 | 1 Jun 70-01 Mar 71 | 380.3 | 179 |
| 35-N | N51-0035-17 | Right Outb'd | 16 thru 64 | 1 Jun 70-01 Mar 71 | 380.3 | 179 |
| 26-N | N51-0035-2 | Left Inb'd | 26 thru 64 | 20 Jul 70-01 Mar 71 | 319.2 | 144 |
| 33-N | N51-0035-12 | Left Outb'd | 26 thru 64 | 20 Jul 70-01 Mar 71 | 319.2 | 144 |
| 38-N | N51-0035-26 | Left Inb'd | 65 thru 67 | 31 Mar-20 Apr 71 | 41.1 | 10 |
| 28-N | N51-0035-16 | Right Outb'd | 65 thru 85 | 31 Mar-15 Jun 71 | 173.0 | 56 |
| 30-N | N51-0035-20 | Right Inb'd | 65 thru 106 | 31 Mar-12 Aug 71 | 343.7 | 161 |
| 37-N | N51-0035-25 | Left Outb'd | 65 thru 115 | 31 Mar-17 Sep 71 | 426.8 | 239 |
| 4A-N | N51-0025-15 | Left Inb'd | 68 thru 115 | 26 Apr-17 Sep 71 | 385.7 | 229 |
| 2A-N | N51-0025-2 | Right Outb'd | 86 thru 115 | 8 Jul-17 Sep 71 | 253.8 | 183 |
| 3A-N | N51-0025-14 | Right Inb'd | 107 thru 115 | 10-17 Sep 71 | 83.1 | 78 |

TABLE IV. SUMMARY OF LANDINGS CONDUCTED AT NORMAL AND HIGH TIRE DEFLECTIONS.

| | Aircraft Gross Weight | Type Landing: Braked Stop | Type Landing: Touch-And-Go | Total Landings |
|---|---|---|---|---|
| Normal Tire Deflection (35%) | Light | 115 | 44 | 159 |
| | Medium | 85 | | 85 |
| | Heavy | 61 | 44 | 105 |
| Sub Total | | 261 | 88 | 349 |
| High Tire Deflection (50%) | Light | 51 | 13 | 64 |
| | Medium | | | |
| | Heavy | 26 | 20 | 46 |
| Sub Total | | 77 | 33 | 110 |
| Total Landings | | 338 | 121 | 459 |

Light = 41,300 to 42,600 lbs
Medium = 47,200 to 49,575 lbs
Heavy = 51,171 to 56,665 lbs

TABLE V. TIRE BLOWOUT AND LOW-SPEED, RUN-FLAT ROLLOUT.
TIRE S/N N51-0035-11. LEFT OUTBOARD MLG POSITION.

| Event | Elapsed Time | | | Speed | | Pressure, psi | |
|---|---|---|---|---|---|---|---|
| | Minutes | Seconds | Milliseconds | Aircraft knots | Wheel rpm | Tire | Left Reservoir |
| Touchdown and Spin up | 0 | 0 | 0 | 111 | 15 | 58 | 633 |
| Wheel Lockup | 0 | 4 | 730 | 103 | 0 | 64 | 588 |
| Start Losing Tire Pressure | 0 | 15 | 170 | 70 | 0 | 63 | 592 |
| Auto Inflate Starts | 0 | 18 | 980 | 58 | 0 | 57 | 588 |
| Tire Spins Up Again | 0 | 21 | 350 | 51 | 15 | 41 | 514 |
| Run-Flat and Rollout | 0 | 23 | 820 | 43 | 392 | 20 | 452 |
| | 0 | 24 | 800 | 41 | 385 | 15 | 437 |
| | 0 | 26 | 930 | 39 | 262 | 10 | 394 |
| | 0 | 33 | 330 | 38 | 207 | 5 | 269 |
| | 1 | 35 | 620 | 23 | 173 | 0 | 0 |
| Stop Roll | 1 | 56 | 840 | 0 | 0 | 0 | 0 |

TABLE VI. SEQUENCE OF EVENTS FOR HIGH SPEED RUN-FLAT ROLLOUT.

| Event | Elapsed Time | | | Speed | | | Vertical Force, lbs | | Pressure, psi | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Minutes | Seconds | Milli-Seconds | Aircraft knots | Wheel, rpm Left | Wheel, rpm Right | Left MLG | Right MLG | Left Tires | Right Tires |
| | 0 | 0 | 0 | 106 | 967 | 1025 | 8592 | 11268 | 51 | 51 |
| Right MLG Tires Started Deflating | 0 | 0 | 080 | 103 | 907 | 924 | 9333 | 11128 | 51 | 49 |
| | 0 | 0 | 230 | 104 | 950 | 982 | 9703 | 11059 | 51 | 32 |
| | 0 | 0 | 380 | 102 | 962 | 844 | 9037 | 10920 | 51 | 15 |
| Left MLG Tires Started Deflating | 0 | 0 | 460 | 103 | 1021 | 1242 | 9481 | 11198 | 50 | 11 |
| | 0 | 0 | 610 | 104 | 950 | 1025 | 8518 | 10920 | 36 | 7 |
| | 0 | 0 | 770 | 105 | 688 | 1365 | 8000 | 10920 | 19 | 6 |
| | 0 | 0 | 840 | 106 | 1043 | 1438 | 8000 | 10711 | 13 | 6 |
| | 0 | 0 | 920 | 107 | 1093 | 1062 | 9481 | 10711 | 9 | 6 |
| | 0 | 1 | 700 | 106 | 1243 | 1043 | 9333 | 10781 | 4 | 5 |
| Maximum Air Speed Recorded | 0 | 3 | 740 | 116 | 981 | 994 | 9037 | 9946 | 2 | 2 |
| | 0 | 13 | 370 | 90 | 772 | 810 | 10963 | 11198 | 2 | 2 |
| | 0 | 24 | 160 | 60 | 612 | 577 | 17703 | 15997 | 1 | 2 |
| Stop Roll | 6 | 41 | 220 | 24 | 82 | 81 | 18592 | 19058 | 1 | 2 |

TABLE VII. PREVIOUS USAGE ON TIRES SELECTED FOR THE HIGH SPEED, RUN-FLAT ROLLOUT EVALUATION.

| Event | Position on Main Landing Gears | | | |
|---|---|---|---|---|
| | Left Outboard | Left Inboard | Right Inboard | Right Outboard |
| Tire Serial Number | N51-0035-17 | N51-0035-2 | N51-0025-14 | N51-0035-12 |
| Tire Code Number | 35-N | 26-N | 3A-N | 33-N |
| Accumulative Ground Run | 380.3 miles | 319.2 miles | 83.1 miles | 319.2 miles |
| Previous Landings: | | | | |
| Touch-and-Go Landings: | | | | |
| 35% Deflection | | | 44 | |
| 50% Deflection | | | 20 | |
| Braked Stop Landings: | | | | |
| 35% Deflection | 179 | 144 | 4 | 144 |
| 50% Deflection | | | 10 | |
| Total Landings | 179 | 144 | 78 | 144 |

TABLE VIII. TREAD WEAR RATES AND LANDING AND MILEAGE PROJECTIONS FOR 38.5/28x13.0-16 FOLDING SIDEWALL TIRES.

| Tire Serial Number | Initial Skid Depth inches | Total Wear inches | Number of Landings | Accum. Ground Run miles | Average Wear Rate | | Landing Projection To Zero Skid landings | Mileage Projection To Zero Skid miles |
|---|---|---|---|---|---|---|---|---|
| | | | | | mils/ldg | mils/mile | | |
| N51-0023-5 | 0.375 | 0.110 | 41 | 80.5 | 2.68 | 1.37 | 140 | 275 |
| N51-0023-7 | 0.336 | 0.086 | 41 | 80.5 | 2.10 | 1.07 | 160 | 315 |
| N51-0023-18 | 0.351 | 0.086 | 41 | 80.5 | 2.10 | 1.07 | 167 | 330 |
| N51-0023-19 | 0.344 | 0.079 | 41 | 80.5 | 1.92 | 0.98 | 178 | 350 |
| N51-0035-11 | 0.344 | 0.064 | 35 | 61.1 | 1.83 | 1.05 | 188 | 328 |
| N51-0035-14 | 0.344 | 0.063 | 35 | 61.1 | 1.80 | 1.03 | 191 | 333 |
| N51-0035-9 | 0.344 | 0.225 | 179 | 380.3 | 1.26 | 0.59 | 273 | 580 |
| N51-0035-17 | 0.344 | 0.250 | 179 | 380.3 | 1.40 | 0.66 | 246 | 522 |
| N51-0035-2 | 0.344 | 0.203 | 144 | 319.2 | 1.41 | 0.64 | 244 | 540 |
| N51-0035-12 | 0.344 | 0.203 | 144 | 319.2 | 1.41 | 0.64 | 244 | 540 |
| N51-0035-26 | 0.328 | 0.030 | 10 | 41.1 | 3.00 | 0.73 | 109 | 447 |
| N51-0035-16 | 0.344 | 0.114 | 56 | 173.0 | 2.04 | 0.66 | 169 | 520 |
| N51-0035-20 | 0.336 | 0.197 | 161 | 343.7 | 1.22 | 0.58 | 275 | 585 |
| N51-0035-25 | 0.344 | 0.298 | 239 | 426.8 | 1.25 | 0.70 | 276 | 493 |
| N51-0025-15 | 0.328 | 0.255 | 229 | 385.7 | 1.11 | 0.66 | 294 | 495 |
| N51-0025-2 | 0.344 | 0.213 | 183 | 253.8 | 1.16 | 0.84 | 296 | 410 |
| N51-0025-14 | 0.328 | 0.110 | 78 | 83.1 | 1.41 | 1.32 | 233 | 248 |
| Totals | 5.822 | 2.586 | 1836 | 3550.4 | 1.41avg | 0.73avg | 243avg | 469avg |

TABLE IX. SUMMARY OF DATA ON DIMENSIONAL GROWTH DUE TO USAGE OF FOLDING SIDEWALL TIRES.

| Tire Serial Number | Tire Code No | Total Number of Landings | Expanded Dimensions | | | | | Folded Dimensions | | | | | Calculated Growth Usage Factors | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $D_{oe}$ (in.) | $H_e$ (in.) | $W_e$ (in.) | $D_{ge}$ (in.) | $W_{ge}$ (in.) | $D_{of}$ (in.) | $H_f$ (in.) | $W_f$ (in.) | $D_{gf}$ (in.) | $W_{gf}$ (in.) | $G_{he}$ | $G_{we}$ | $G_{hf}$ | $G_{wf}$ |
| N51-0035-9 | 31-N | 179 | 37.81 | 10.90 | 12.45 | 38.22 | | 27.55 | 5.78 | 11.75 | 28.96 | 12.14 | 2.04 | | 2.24 | 1.03 |
| N51-0035-17 | 35-N | 179 | 37.84 | 10.92 | 12.42 | 38.23 | | 27.97 | 5.99 | 11.83 | | | 2.04 | | | |
| N51-0035-2 | 26-N | 144 | 37.94 | 10.97 | 12.56 | 38.33 | | 28.00 | 6.00 | 11.61 | | | 2.04 | | | |
| N51-0035-12 | 33-N | 144 | 37.78 | 10.89 | 12.42 | 38.06 | | 28.09 | 6.05 | 11.53 | | | 2.03 | | | |
| N51-0035-16 | 28-N | 56 | 37.81 | 10.90 | 12.44 | 37.88 | 12.67 | 27.98 | 5.99 | 11.66 | 28.83 | 12.09 | 2.01 | 1.02 | 2.14 | 1.04 |
| N51-0035-20 | 30-N | 161 | 37.61 | 10.81 | 12.35 | 38.23 | | 28.00 | 6.00 | 11.86 | 29.38 | 11.96 | 2.06 | | 2.23 | 1.01 |
| N51-0035-25 | 37-N | 239 | 37.72 | 10.86 | 12.47 | 38.02 | | 27.73 | 5.87 | 11.64 | 29.20 | 11.94 | 2.03 | | 2.24 | 1.03 |
| N51-0025-15 | 4A-N | 229 | 37.70 | 10.85 | 12.53 | 38.00 | | 28.25 | 6.13 | 11.89 | 28.89 | 12.02 | 2.03 | | 2.10 | 1.01 |
| N51-0025-2 | 2A-N | 183 | 37.70 | 10.85 | 12.72 | 38.03 | | 28.30 | 6.15 | 12.00 | 29.11 | 12.07 | 2.03 | | 2.13 | 1.01 |
| N51-0025-14 | 3A-N | 78 | 37.92 | 10.96 | 12.95 | 38.31 | | 27.81 | 5.91 | | | | 2.04 | | | |

NOTE: Refer to the description of symbols listed in the Dimensional Growth subsection of this report. All dimensions are in inches. Rim ledge diameter, D, for the 38.5/28x13.0-16 tire is 16 inches.

TABLE X. WEAR DATA ON TIRE S/N N51-0023-5. TEST FLIGHT 1 THRU 15.
RIGHT INBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| | None | None | | 75 | 0.406 | 0.391 | 0.375 | 0.375 | 0.391 | 0.406 | | |
| 7 Apr 70 | 14 | 31.2 | | 63 | 0.344 | 0.313 | 0.313 | 0.313 | 0.313 | 0.344 | 0.062 | 4.4 |
| 6 May 70 | 28 | 54.3 | | 60 | | 0.313 | 0.280 | 0.280 | 0.313 | | 0.095 | 3.4 |
| 22 May 70 | 41 | 80.5 | | 58 | | 0.296 | 0.265 | 0.265 | 0.296 | | 0.110 | 2.7 |

TABLE XI. WEAR DATA ON TIRE S/N N51-0023-7. TEST FLIGHT 1 THRU 15.
LEFT OUTBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| | None | None | | 75 | 0.344 | 0.359 | 0.328 | 0.344 | 0.359 | 0.375 | | |
| 7 Apr 70 | 14 | 31.2 | | 62 | | 0.329 | 0.313 | 0.313 | 0.329 | | 0.023 | 1.6 |
| 6 May 70 | 28 | 54.3 | | 60 | | 0.313 | 0.280 | 0.280 | 0.313 | | 0.056 | 2.0 |
| 22 May 70 | 41 | 80.5 | | 58 | 0.345 | 0.296 | 0.250 | 0.250 | 0.296 | 0.345 | 0.086 | 2.1 |

TABLE XII. WEAR DATA ON TIRE S/N N51-0023-18. TEST FLIGHT 1 THRU 15.
LEFT INBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| | None | None | | 75 | 0.375 | 0.359 | 0.359 | 0.344 | 0.359 | 0.375 | | |
| 7 Apr 70 | 14 | 31.2 | | 62 | | 0.313 | 0.313 | 0.313 | 0.313 | | 0.038 | 2.7 |
| 6 May 70 | 28 | 54.3 | | 60 | | 0.313 | 0.280 | 0.280 | 0.296 | | 0.071 | 2.5 |
| 22 May 70 | 41 | 80.5 | | 58 | 0.345 | 0.296 | 0.265 | 0.265 | 0.296 | 0.345 | 0.086 | 2.1 |

TABLE XIII. WEAR DATA ON TIRE S/N N51-0023-19. TEST FLIGHT 1 THRU 15.
RIGHT OUTBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| | None | None | | 75 | 0.359 | 0.359 | 0.344 | 0.344 | 0.359 | 0.375 | | |
| 7 Apr 70 | 14 | 31.2 | | 63 | | 0.329 | 0.296 | 0.296 | 0.313 | | 0.048 | 3.4 |
| 6 May 70 | 28 | 54.3 | | 60 | | 0.312 | 0.280 | 0.274 | 0.296 | | 0.067 | 2.4 |
| 22 May 70 | 41 | 80.5 | | 58 | 0.345 | 0.296 | 0.265 | 0.265 | 0.296 | 0.345 | 0.079 | 1.9 |

NOTE: Tire removed from the aircraft because of a flat spot.

TABLE XIV. WEAR DATA ON TIRE S/N N51-0035-11. TEST FLIGHT 16 THRU 25.
LEFT OUTBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 1 Jun 70 | None | None | 37.27 | 57 | 0.391 | 0.360 | 0.344 | 0.344 | 0.360 | 0.391 | | |
| 3 Jun 70 | 7 | 13.3 | | 57 | | 0.344 | 0.328 | 0.328 | 0.344 | | 0.016 | 2.3 |
| 11 Jun 70 | 19 | 32.1 | | 60 | 0.375 | 0.328 | 0.296 | 0.296 | 0.328 | 0.375 | 0.048 | 2.5 |
| 2 Jul 70 | 31 | 54.8 | | 64 | | 0.313 | 0.280 | 0.280 | 0.313 | | 0.064 | 2.1 |

NOTES: Tire Blowout occurred on 35th landing due to wheel lockup.

Maximum temperature indicated on the "tempilabel" was 160°F.

TABLE XV. WEAR DATA ON TIRE S/N N51-0035-14. TEST FLIGHT 16 THRU 25. LEFT INBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 1 Jun 70 | None | None | 37.53 | 57 | 0.391 | 0.344 | 0.344 | 0.344 | 0.344 | 0.391 | | |
| 3 Jun 70 | 7 | 13.3 | | 57 | | 0.344 | 0.328 | 0.328 | 0.344 | | 0.016 | 2.3 |
| 11 Jun 70 | 19 | 32.1 | | 60 | 0.375 | 0.328 | 0.296 | 0.296 | 0.328 | 0.375 | 0.048 | 2.5 |
| 2 Jul 70 | 31 | 54.8 | | 64 | | 0.313 | 0.290 | 0.290 | 0.313 | | 0.054 | 1.7 |
| 9 Jul 70 | 35 | 61.1 | 37.44 | 60 | 0.359 | 0.313 | 0.281 | 0.281 | 0.313 | 0.359 | 0.063 | 1.8 |
| | | | 37.56 | 75 | | | | | | | | |

NOTES: 142.8 oz. in. unbalance at completion of test while tire was inflated.

Maximum temperature indicated on the "tempilabel" was 160°F.

TABLE XVI. WEAR DATA ON TIRE S/N N51-0035-9. TEST FLIGHT 16 THRU 64. RIGHT INBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landings |
| 1 Jun 70 | None | None | 37.55 | 57 | 0.375 | 0.344 | 0.344 | 0.344 | 0.344 | 0.375 | | |
| 3 Jun 70 | 7 | 13.3 | | 57 | | 0.344 | 0.328 | 0.328 | 0.344 | | 0.016 | 2.3 |
| 11 Jun 70 | 19 | 32.1 | | 60 | | 0.328 | 0.313 | 0.313 | 0.328 | | 0.031 | 1.6 |
| 2 Jul 70 | 31 | 54.8 | | 64 | | 0.313 | 0.290 | 0.290 | 0.313 | | 0.054 | 1.7 |
| 9 Jul 70 | 35 | 61.1 | 37.88 | 54 | | 0.313 | 0.280 | 0.280 | 0.313 | | 0.064 | 1.8 |
| 24 Jul 70 | 49 | 87.5 | | 60 | | 0.296 | 0.273 | 0.273 | 0.313 | | 0.071 | 1.5 |
| 3 Aug 70 | 65 | 112.5 | | 57 | | 0.288 | 0.250 | 0.250 | 0.296 | | 0.094 | 1.4 |
| 14 Aug 70 | 82 | 141.2 | | 65 | 0.328 | 0.265 | 0.200 | 0.200 | 0.281 | 0.328 | 0.144 | 1.7 |
| 28 Aug 70 | 109 | 188.9 | | 72 | | 0.241 | 0.172 | 0.172 | 0.265 | | 0.172 | 1.6 |
| 14 Oct 70 | 124 | 226.7 | | 71 | | 0.229 | 0.169 | 0.169 | 0.260 | | 0.175 | 1.4 |
| 16 Nov 70 | 136 | 271.5 | | 90 | 0.306 | 0.212 | 0.161 | 0.161 | 0.211 | 0.300 | 0.183 | 1.3 |
| 9 Dec 70 | 149 | 326.4 | | 89 | | 0.198 | 0.158 | 0.159 | 0.203 | | 0.186 | 1.3 |
| 9 Mar 71 | 179 | 380.3 | 38.22 | 75 | 0.263 | 0.168 | 0.120 | 0.118 | 0.197 | 0.284 | 0.225 | 1.3 |

TABLE XVII. WEAR DATA ON TIRE S/N N51-0035-17. TEST FLIGHT 16 THRU 64. RIGHT OUTBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 1 Jun 70 | None | None | 37.58 | 57 | 0.375 | 0.344 | 0.344 | 0.344 | 0.344 | 0.375 | | |
| 3 Jun 70 | 7 | 13.3 | | 57 | | 0.344 | 0.328 | 0.328 | 0.344 | | 0.016 | 2.3 |
| 11 Jun 70 | 19 | 32.1 | | 60 | | 0.328 | 0.305 | 0.305 | 0.328 | | 0.039 | 2.1 |
| 2 Jul 70 | 31 | 54.8 | | 64 | | 0.313 | 0.290 | 0.290 | 0.313 | | 0.054 | 1.7 |
| 9 Jul 70 | 35 | 61.1 | 37.91 | 54 | | 0.313 | 0.280 | 0.280 | 0.313 | | 0.064 | 1.8 |
| 24 Jul 70 | 49 | 87.5 | | 60 | | 0.313 | 0.273 | 0.273 | 0.313 | | 0.071 | 1.5 |
| 3 Aug 70 | 65 | 112.5 | | 57 | | 0.296 | 0.250 | 0.250 | 0.296 | | 0.094 | 1.4 |
| 14 Aug 70 | 82 | 141.2 | | 65 | 0.344 | 0.280 | 0.210 | 0.210 | 0.280 | 0.344 | 0.134 | 1.6 |
| 28 Aug 70 | 109 | 188.9 | | 72 | | 0.280 | 0.187 | 0.187 | 0.280 | | 0.157 | 1.4 |
| 14 Oct 70 | 124 | 226.7 | | 71 | | 0.267 | 0.169 | 0.176 | 0.280 | | 0.171 | 1.4 |
| 16 Nov 70 | 136 | 271.5 | | 90 | 0.317 | 0.226 | 0.150 | 0.154 | 0.254 | 0.317 | 0.192 | 1.4 |
| 9 Dec 70 | 149 | 326.4 | | 89 | | 0.215 | 0.121 | 0.126 | 0.229 | | 0.220 | 1.5 |
| 9 Mar 71 | 179 | 380.3 | 38.23 | 75 | 0.288 | 0.185 | 0.091 | 0.098 | 0.211 | 0.302 | 0.250 | 1.4 |

TABLE XVIII. WEAR DATA ON TIRE S/N N51-0035-2. TEST FLIGHT 26 THRU 64. LEFT INBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 16 Jul 70 | None | None | 37.41 | 60 | 0.391 | 0.375 | 0.344 | 0.344 | 0.375 | 0.391 | | |
| 24 Jul 70 | 14 | 26.4 | | 60 | | 0.328 | 0.313 | 0.313 | 0.328 | | 0.031 | 2.2 |
| 3 Aug 70 | 30 | 51.4 | | 55 | | 0.313 | 0.280 | 0.280 | 0.313 | | 0.064 | 2.1 |
| 14 Aug 70 | 47 | 80.0 | | 64 | 0.375 | 0.296 | 0.257 | 0.257 | 0.296 | 0.375 | 0.087 | 1.9 |
| 28 Aug 70 | 74 | 127.8 | | 72 | | 0.288 | 0.234 | 0.234 | 0.288 | | 0.110 | 1.5 |
| 14 Oct 70 | 89 | 165.6 | | 72 | | 0.281 | 0.220 | 0.220 | 0.281 | | 0.124 | 1.4 |
| 16 Nov 70 | 101 | 210.4 | | 90 | 0.334 | 0.261 | 0.181 | 0.178 | 0.272 | 0.334 | 0.164 | 1.6 |
| 9 Dec 70 | 114 | 261.2 | | 86 | | 0.235 | 0.179 | 0.175 | 0.244 | | 0.167 | 1.5 |
| 9 Mar 71 | 144 | 319.2 | 38.33 | 77 | 0.303 | 0.216 | 0.142 | 0.141 | 0.219 | 0.302 | 0.203 | 1.4 |

TABLE XIX. WEAR DATA ON TIRE S/N N51-0035-12. TEST FLIGHT 26 THRU 64. LEFT OUTBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear to center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 16 Jul 70 | None | None | 37.28 | 60 | 0.391 | 0.375 | 0.344 | 0.344 | 0.375 | 0.391 | | |
| 24 Jul 70 | 14 | 26.4 | | 60 | | 0.344 | 0.313 | 0.313 | 0.344 | | 0.031 | 2.2 |
| 3 Aug 70 | 30 | 51.4 | | 55 | | 0.313 | 0.280 | 0.280 | 0.313 | | 0.064 | 2.1 |
| 14 Aug 70 | 47 | 80.0 | | 64 | 0.360 | 0.304 | 0.257 | 0.257 | 0.304 | 0.360 | 0.087 | 1.9 |
| 28 Aug 70 | 74 | 127.8 | | 72 | | 0.288 | 0.223 | 0.223 | 0.288 | | 0.121 | 1.7 |
| 14 Oct 70 | 89 | 165.6 | | 72 | | 0.275 | 0.220 | 0.220 | 0.275 | | 0.124 | 1.4 |
| 16 Nov 70 | 101 | 210.4 | | 90 | 0.329 | 0.270 | 0.214 | 0.212 | 0.253 | 0.317 | 0.131 | 1.3 |
| 9 Dec 70 | 114 | 261.2 | | 86 | | 0.250 | 0.186 | 0.176 | 0.250 | | 0.163 | 1.4 |
| 9 Mar 71 | 144 | 319.2 | 38.06 | 77 | 0.297 | 0.216 | 0.141 | 0.142 | 0.231 | 0.299 | 0.203 | 1.4 |

TABLE XX. WEAR DATA ON TIRE S/N N51-0035-26. TEST FLIGHT 65 THRU 67. LEFT INBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 19 Mar 71 | None | None | 37.80 | 75 | 0.375 | 0.344 | 0.328 | 0.328 | 0.344 | 0.375 | | |
| 21 Apr 71 | 10 | 41.1 | 38.75 | 72 | 0.375 | 0.332 | 0.300 | 0.296 | 0.322 | 0.361 | 0.030 | 3.0 |

NOTE: Tire removed from aircraft because of blister in sidewall (90° circumferentially). Folded away from strut centerline.

TABLE XXI. WEAR DATA ON TIRE S/N N51-0035-16. TEST FLIGHT 65 THRU 85. RIGHT OUTBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 19 Mar 71 | None | None | 37.81 | 75 | 0.383 | 0.352 | 0.344 | 0.344 | 0.352 | 0.383 | | |
| 21 Apr 71 | 10 | 41.1 | 38.52 | 79 | 0.360 | 0.313 | 0.296 | 0.296 | 0.313 | 0.360 | 0.048 | 4.8 |
| 14 May 71 | 20 | 100.2 | | 80 | | 0.296 | 0.265 | 0.263 | 0.304 | | 0.080 | 4.0 |
| 21 May 71 | 32 | 122.3 | | 79 | 0.326 | 0.288 | 0.254 | 0.252 | 0.296 | 0.324 | 0.091 | 2.8 |
| 11 Jun 71 | 48 | 157.0 | | 78 | 0.304 | 0.288 | 0.239 | 0.236 | 0.295 | 0.322 | 0.107 | 2.2 |
| 15 Jul 71 | 56 | 173.0 | 37.88 | 75 | 0.304 | 0.282 | 0.228 | 0.232 | 0.284 | 0.320 | 0.114 | 2.0 |

NOTES: After 56 landings, the tire kicked outboard on inflation th. the normal valve stem; but shifted inboard on deflation. Tire folded to center position.

The tire was removed from the aircraft on 30 Jun 71. Condition of tire after test:

(a) Small splits on inboard sidewall, exposing the outer ply cords.
(b) Cut in tire tread crown (2 1/2" long X 5/32" deep)
(c) Slight chafing of the brake drive bolts against inboard lower sidewall.

Maximum temp. indicated on the "tempilabel" was 180°F.

TABLE XXII. WEAR DATA ON TIRE S/N N51-0035-20. TEST FLIGHT 65 THRU 106. RIGHT INBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 19 Mar 71 | None | None | 37.61 | 75 | 0.375 | 0.344 | 0.336 | 0.336 | 0.344 | 0.375 | | |
| 21 Apr 71 | 10 | 41.1 | 38.66 | 79 | 0.363 | 0.322 | 0.293 | 0.293 | 0.322 | 0.360 | 0.043 | 4.3 |
| 14 May 71 | 20 | 100.2 | | 80 | | 0.288 | 0.273 | 0.271 | 0.296 | | 0.064 | 3.2 |
| 21 May 71 | 32 | 122.3 | | 79 | 0.324 | 0.284 | 0.268 | 0.264 | 0.294 | 0.328 | 0.070 | 2.2 |
| 11 Jun 71 | 48 | 157.0 | | 78 | 0.315 | 0.280 | 0.242 | 0.234 | 0.281 | 0.313 | 0.098 | 2.0 |
| 14 Jul 71 | 68 | 198.1 | | 76 | 0.290 | 0.259 | 0.213 | 0.212 | 0.262 | 0.290 | 0.124 | 1.8 |
| 21 Jul 71 | 107 | 226.5 | | 80 | 0.285 | 0.246 | 0.182 | 0.184 | 0.248 | 0.283 | 0.152 | 1.4 |
| 28 Jul 71 | 119 | 267.0 | | 80 | 0.279 | 0.237 | 0.170 | 0.168 | 0.244 | 0.279 | 0.167 | 1.4 |
| 4 Aug 71 | 145 | 293.7 | | 80 | | 0.226 | 0.156 | 0.158 | 0.233 | | 0.179 | 1.2 |
| 23 Aug 71 | 161 | 343.7 | 38.23 | 75 | 0.250 | 0.201 | 0.139 | 0.139 | 0.223 | 0.245 | 0.197 | 1.2 |

NOTES: Folding quality was poor after 161 landings. Tire folded away from strut centerline and stayed. A split in the outboard sidewall progressed to 41" long in circumference.

Maximum temperature indicated on the "tempilabel" was 230°F.

TABLE XXIII. WEAR DATA ON TIRE S/N N51-0035-25. TEST FLIGHT 65 THRU 115. LEFT OUTBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 19 Mar 71 | None | None | 37.72 | 75 | 0.375 | 0.359 | 0.344 | 0.344 | 0.359 | 0.379 | | |
| 21 Apr 71 | 10 | 41.1 | 38.48 | 72 | 0.365 | 0.318 | 0.301 | 0.301 | 0.315 | 0.354 | 0.043 | 4.3 |
| 14 May 71 | 20 | 100.2 | | 83 | | 0.288 | 0.260 | 0.255 | 0.288 | | 0.087 | 4.3 |
| 21 May 71 | 32 | 122.3 | | 81 | 0.329 | 0.282 | 0.256 | 0.247 | 0.285 | 0.316 | 0.093 | 2.9 |
| 11 Jun 71 | 48 | 157.0 | | 82 | 0.307 | 0.282 | 0.223 | 0.216 | 0.282 | 0.306 | 0.125 | 2.6 |
| 14 Jul 71 | 68 | 198.1 | | 80 | 0.289 | 0.271 | 0.203 | 0.198 | 0.265 | 0.287 | 0.144 | 2.1 |
| 21 Jul 71 | 107 | 226.5 | | 80 | 0.286 | 0.267 | 0.179 | 0.175 | 0.260 | 0.286 | 0.167 | 1.6 |
| 28 Jul 71 | 119 | 267.0 | | 83 | 0.283 | 0.256 | 0.165 | 0.163 | 0.250 | 0.281 | 0.180 | 1.5 |
| 4 Aug 71 | 145 | 293.7 | | 85 | | 0.248 | 0.156 | 0.150 | 0.238 | | 0.191 | 1.3 |
| 23 Aug 71 | 161 | 343.7 | 38.27 | 78 | 0.252 | 0.248 | 0.122 | 0.121 | 0.206 | 0.243 | 0.223 | 1.4 |
| 13 Sep 71 | 185 | 366.5 | | 78 | 0.248 | 0.198 | 0.097 | 0.094 | 0.195 | 0.243 | 0.249 | 1.3 |
| 14 Sep 71 | 207 | 383.6 | | 78 | | 0.197 | 0.058 | 0.060 | 0.192 | | 0.285 | 1.4 |
| 22 Sep 71 | 239 | 426.8 | 38.02 | 78 | 0.233 | 0.183 | 0.047 | 0.046 | 0.180 | 0.223 | 0.298 | 1.2 |

NOTES: Good folding quality after 161 landings, tire folded and unfolded towards strut centerline.

After 239 Landings, tire folded towards strut centerline and stayed. Was easily forced to center by hand.

Tire was removed from aircraft on 22 Sept 71.

Maximum temperature indicated on the "tempilabel" was 230°F.

TABLE XXIV. WEAR DATA ON TIRE S/N N51-0025-15. TEST FLIGHT 68 THRU 115. LEFT INBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 23 Apr 71 | None | None | 37.70 | 75 | 0.375 | 0.359 | 0.328 | 0.328 | 0.359 | 0.375 | | |
| 14 May 71 | 10 | 59.1 | | 83 | 0.344 | 0.309 | 0.288 | 0.288 | 0.312 | 0.344 | 0.040 | 4.0 |
| 21 May 71 | 22 | 81.2 | | 81 | 0.324 | 0.307 | 0.281 | 0.281 | 0.312 | 0.332 | 0.047 | 2.1 |
| 11 Jun 71 | 38 | 115.9 | | 82 | 0.308 | 0.288 | 0.243 | 0.243 | 0.290 | 0.311 | 0.085 | 2.2 |
| 14 Jul 71 | 58 | 157.0 | | 80 | 0.288 | 0.280 | 0.228 | 0.230 | 0.283 | 0.288 | 0.099 | 1.7 |
| 21 Jul 71 | 97 | 185.4 | | 80 | 0.287 | 0.275 | 0.196 | 0.196 | 0.278 | 0.288 | 0.132 | 1.4 |
| 28 Jul 71 | 109 | 225.9 | | 83 | 0.287 | 0.257 | 0.182 | 0.182 | 0.270 | 0.287 | 0.146 | 1.3 |
| 4 Aug 71 | 135 | 252.6 | | 85 | | 0.253 | 0.171 | 0.173 | 0.259 | | 0.156 | 1.2 |
| 23 Aug 71 | 151 | 302.6 | 38.23 | 78 | 0.248 | 0.226 | 0.141 | 0.142 | 0.231 | 0.244 | 0.187 | 1.2 |
| 13 Sep 71 | 175 | 325.4 | | 78 | 0.245 | 0.209 | 0.124 | 0.123 | 0.220 | 0.237 | 0.205 | 1.2 |
| 14 Sep 71 | 197 | 342.5 | | 78 | | 0.208 | 0.101 | 0.101 | 0.218 | | 0.227 | 1.1 |
| 22 Sep 71 | 229 | 385.7 | 38.00 | 78 | 0.214 | 0.183 | 0.072 | 0.075 | 0.194 | 0.207 | 0.255 | 1.1 |

NOTES: Folding quality good after 151 landings. Tire folded and unfolded towards strut centerline.

After 229 landings, tire folded towards strut centerline and stayed. Tire was easily forced to center position by hand.

Maximum temperature indicated on the "tempilabel" was 230°F.

TABLE XXV. WEAR DATA ON TIRE S/N N51-0025-2. TEST FLIGHT 86 THRU 115. RIGHT OUTBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 6 Jul 71 | None | None | 37.70 | 57 | 0.375 | 0.359 | 0.344 | 0.344 | 0.359 | 0.375 | | |
| 14 Jul 71 | 12 | 25.1 | | 76 | 0.359 | 0.336 | 0.316 | 0.316 | 0.336 | 0.359 | 0.028 | 2.3 |
| 21 Jul 71 | 51 | 53.5 | | 80 | 0.348 | 0.319 | 0.283 | 0.283 | 0.316 | 0.346 | 0.061 | 1.2 |
| 28 Jul 71 | 63 | 94.0 | | 80 | 0.346 | 0.311 | 0.273 | 0.273 | 0.311 | 0.346 | 0.071 | 1.1 |
| 4 Aug 71 | 89 | 120.7 | | 80 | 0.344 | 0.300 | 0.247 | 0.247 | 0.300 | 0.344 | 0.097 | 1.1 |
| 23 Aug 71 | 105 | 170.7 | 38.20 | 75 | 0.306 | 0.284 | 0.218 | 0.218 | 0.284 | 0.313 | 0.126 | 1.2 |
| 13 Sep 71 | 129 | 193.5 | | 78 | 0.293 | 0.280 | 0.191 | 0.189 | 0.284 | 0.304 | 0.154 | 1.2 |
| 14 Sep 71 | 151 | 210.6 | | 78 | | 0.271 | 0.183 | 0.179 | 0.278 | | 0.163 | 1.1 |
| 22 Sep 71 | 183 | 253.8 | 38.03 | 78 | 0.276 | 0.244 | 0.131 | 0.131 | 0.247 | 0.291 | 0.213 | 1.2 |

NOTES: After 105 landings, folded towards strut centerline and was very slow recentering.

After 183 landings, tire folded towards strut centerline and stayed. Tire was forced to center with much effort by hand.

Maximum temperature indicated on the "tempilabel" was 230°F.

TABLE XXVI. WEAR DATA ON TIRE S/N N51-0025-14. TEST FLIGHT 107 THRU 115. RIGHT INBOARD MLG POSITION.

| Date | Landings | Accum Ground Run (miles) | Tire O.D. (inches) | Inflation Pressure (psig) | Tread Groove Depth (Refer to Figure 30) (inch) | | | | | | Average Wear at center grooves 3 & 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | (inch) | mils per landing |
| 24 Aug 71 | None | None | 37.92 | 75 | 0.375 | 0.344 | 0.328 | 0.328 | 0.344 | 0.375 | | |
| 13 Sep 71 | 24 | 22.8 | | 78 | 0.354 | 0.329 | 0.278 | 0.278 | 0.321 | 0.360 | 0.050 | 2.1 |
| 14 Sep 71 | 46 | 39.9 | | 78 | | 0.317 | 0.264 | 0.264 | 0.314 | | 0.064 | 1.4 |
| 22 Sep 71 | 78 | 83.1 | 38.31 | 78 | 0.322 | 0.294 | 0.218 | 0.218 | 0.301 | 0.333 | 0.110 | 1.4 |

NOTE: After 78 landings, tire folded towards strut centerline within 6 to 8 seconds and then slowly (approximately 20 seconds) returned to center.

TABLE XXVII. LANDINGS MADE DURING THE TEST.

| Aircraft Weight | Tire Deflection | Number of Landings | | |
|---|---|---|---|---|
| | | Full stop | Touch and go | Total |
| 42,000 lbs | 35% | 53 | 44 | 97 |
| 42,000 lbs | 50% | 51 | 13 | 64 |
| 48,000 lbs | 35% | 84 | 0 | 84 |
| 48,000 lbs | 50% | | | |
| 51,000 lbs | 35% | 6 | 12 | 18* |
| 51,000 lbs | 50% | 24 | 20 | 44 |
| 56,000 lbs | 35% | 44 | 0 | 44 |
| 56,000 lbs | 50% | | | |

*Because of the small sample size the 51,000 lbs 35% deflection category was not used in the analysis.

TABLE XXVIII. FREQUENCY DISTRIBUTIONS OF VERTICAL LOADS.

NOTE: These data were obtained by lumping peak loads measured for the left and right MLG together. Thus, the table represents a composite peak load for a single MLG on the test aircraft. This also applies to frequency of occurrence plots in Figures 31 through 35 since they were obtained from the data in this table.

| Vert. Force Increment lbs x 1000 | Number of Occurrences (Impact) | | | | |
|---|---|---|---|---|---|
| | 35% Deflection | | | 50% Deflection | |
| | 42,000 lbs GW | 48,000 lbs GW | 56,000 lbs GW | 42,000 lbs GW | 51,000 lbs GW |
| 1 to 2 | 0 | 0 | 0 | 0 | 1 |
| 2 to 3 | 0 | 0 | 0 | 2 | 0 |
| 3 to 4 | 4 | 2 | 1 | 0 | 0 |
| 4 to 5 | 2 | 3 | 0 | 6 | 1 |
| 5 to 6 | 10 | 9 | 2 | 4 | 1 |
| 6 to 7 | 5 | 7 | 0 | 9 | 5 |
| 7 to 8 | 11 | 6 | 0 | 8 | 5 |
| 8 to 9 | 3 | 15 | 4 | 8 | 7 |
| 9 to 10 | 10 | 20 | 2 | 10 | 7 |
| 10 to 11 | 18 | 33 | 5 | 11 | 3 |
| 11 to 12 | 8 | 24 | 12 | 16 | 8 |
| 12 to 13 | 5 | 20 | 6 | 14 | 10 |
| 13 to 14 | 11 | 13 | 9 | 11 | 15 |
| 14 to 15 | 5 | 10 | 11 | 13 | 13 |
| 15 to 16 | 2 | 4 | 8 | 8 | 5 |
| 16 to 17 | 2 | 1 | 13 | 6 | 6 |
| 17 to 18 | 1 | 1 | 6 | 1 | 1 |
| 18 to 19 | 0 | 0 | 4 | 1 | 0 |
| 19 to 20 | 0 | 0 | 0 | 0 | 0 |
| 20 to 21 | 0 | 0 | 4 | 0 | 0 |
| 21 to 22 | 0 | 0 | 1 | 0 | 0 |
| Total | 194 | 168 | 88 | 128 | 88 |

| Vert. Force Increment lbs x 1000 | Number of Occurrences (Overall) | | | | |
|---|---|---|---|---|---|
| | 35% Deflection | | | 50% Deflection | |
| | 42,000 lbs GW | 48,000 lbs GW | 56,000 lbs GW | 42,000 lbs GW | 51,000 lbs GW |
| 7 to 8 | 1 | 0 | 0 | 0 | 0 |
| 8 to 9 | 0 | 0 | 0 | 0 | 0 |
| 9 to 10 | 1 | 0 | 0 | 0 | 0 |
| 10 to 11 | 2 | 0 | 0 | 0 | 0 |
| 11 to 12 | 9 | 0 | 0 | 4 | 0 |
| 12 to 13 | 13 | 0 | 0 | 7 | 3 |
| 13 to 14 | 25 | 0 | 0 | 6 | 3 |
| 14 to 15 | 21 | 0 | 0 | 4 | 11 |
| 15 to 16 | 13 | 0 | 0 | 3 | 6 |
| 16 to 17 | 14 | 0 | 0 | 4 | 6 |
| 17 to 18 | 15 | 1 | 0 | 23 | 3 |
| 18 to 19 | 31 | 12 | 0 | 40 | 5 |
| 19 to 20 | 28 | 33 | 0 | 21 | 1 |
| 20 to 21 | 13 | 48 | 0 | 10 | 3 |
| 21 to 22 | 5 | 46 | 0 | 6 | 7 |
| 22 to 23 | 2 | 14 | 0 | 0 | 10 |
| 23 to 24 | 1 | 8 | 4 | 0 | 12 |
| 24 to 25 | 0 | 5 | 8 | 0 | 8 |
| 25 to 26 | 0 | 1 | 20 | 0 | 6 |
| 26 to 27 | 0 | 0 | 18 | 0 | 1 |
| 27 to 28 | 0 | 0 | 17 | 0 | 2 |
| 28 to 29 | 0 | 0 | 13 | 0 | 0 |
| 29 to 30 | 0 | 0 | 4 | 0 | 1 |
| 30 to 31 | 0 | 0 | 1 | 0 | 0 |
| 31 to 32 | 0 | 0 | 2 | 0 | 0 |
| 32 to 33 | 0 | 0 | 1 | 0 | 0 |
| Total | 194 | 168 | 88 | 128 | 88 |

TABLE XXIX. FREQUENCY DISTRIBUTION OF DRAG LOADS.

NOTE: These data were obtained by lumping peak loads measured for the left and right MLG together. Thus, the table represents a composite peak load for a single MLG on the test aircraft. This also applies to the frequency of occurrence plots in Figures 37 through 41 since they were obtained from the data in this table.

| Drag Force Increment lbs x 100 | Number of Occurrences (Impact) | | | | | Number of Occurrences (Overall) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 35% Deflection | | | 50% Deflection | | 35% Deflection | | | 50% Deflection | |
| | 42,000 lbs GW | 48,000 lbs GW | 56,000 lbs GW | 42,000 lbs GW | 51,000 lbs GW | 42,000 lbs GW | 48,000 lbs GW | 56,000 lbs GW | 42,000 lbs GW | 51,000 lbs GW |
| 0 to 5 | 1 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 5 to 10 | 0 | 5 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 10 to 15 | 6 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 15 to 20 | 9 | 7 | 0 | 1 | 5 | 4 | 0 | 0 | 1 | 6 |
| 20 to 25 | 10 | 6 | 1 | 11 | 2 | 5 | 0 | 0 | 4 | 1 |
| 25 to 30 | 13 | 12 | 3 | 4 | 4 | 5 | 2 | 0 | 3 | 2 |
| 30 to 35 | 17 | 14 | 10 | 11 | 8 | 8 | 6 | 1 | 7 | 7 |
| 35 to 40 | 22 | 22 | 6 | 15 | 5 | 21 | 17 | 1 | 19 | 4 |
| 40 to 45 | 16 | 18 | 5 | 14 | 11 | 18 | 9 | 4 | 9 | 12 |
| 45 to 50 | 13 | 21 | 6 | 6 | 9 | 16 | 18 | 8 | 12 | 8 |
| 50 to 55 | 16 | 14 | 12 | 8 | 13 | 26 | 20 | 15 | 8 | 12 |
| 55 to 60 | 25 | 11 | 11 | 10 | 9 | 23 | 24 | 15 | 15 | 11 |
| 60 to 65 | 14 | 9 | 9 | 8 | 4 | 16 | 22 | 15 | 11 | 5 |
| 65 to 70 | 6 | 5 | 4 | 6 | 5 | 13 | 17 | 5 | 8 | 9 |
| 70 to 75 | 8 | 9 | 4 | 6 | 1 | 11 | 15 | 8 | 8 | 1 |
| 75 to 80 | 8 | 1 | 6 | 3 | 4 | 9 | 5 | 9 | 4 | 4 |
| 80 to 85 | 4 | 4 | 4 | 2 | 0 | 7 | 6 | 4 | 2 | 0 |
| 85 to 90 | 1 | 3 | 1 | 1 | 2 | 2 | 5 | 1 | 1 | 2 |
| 90 to 95 | 1 | 0 | 2 | 4 | 0 | 1 | 1 | 1 | 4 | 0 |
| 95 to 100 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 100 to 105 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| Total | 192 | 167 | 88 | 114 | 85 | 188 | 167 | 88 | 118 | 84 |